

PROPERTY OF
APOLLO TECH. INFO. SERV.
GENERAL ELECTRIC CO.

Task ISA

New publication
out
Feb. 1963

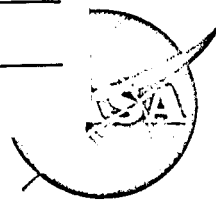
STAGE CHECKOUT PLAN

5 AUGUST 1963

N 66-16 145

FACILITY FORM 802

(ACCESSION NUMBER)	(THRU)
121	1
(PAGES)	(CODE)
CR 69710	11
(NASA CR OR TMX OR AD NUMBER)	(CATEGORY)



GPO PRICE \$

CFSTI PRICE(S) \$

Hard copy (HC) 4.00

Microfiche (MF) 1.00

ACCESSION NUMBER
N 10920
APOLLO TECH. INFO. SERV.

ff 653 July 65

Prepared for

QUALITY ASSURANCE DIVISION
MARSHALL SPACE FLIGHT CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

STAGE CHECKOUT PLAN

5 August 1963

Prepared For
Quality Assurance Division
Marshall Space Flight Center
National Aeronautics and Space Administration

TABLE OF CONTENTS

<u>Paragraph</u>	<u>Title</u>	
1.0	INTRODUCTION AND SCOPE	
1.1	GENERAL	1-1
1.2	REFERENCED DOCUMENTS	1-4
2.0	ASSEMBLED STAGE CHECKOUT	2-1
2.1	INTRODUCTION	2-1
2.2	SCOPE	2-3
2.3	GENERAL GUIDELINES	2-4
2.4	PROGRAM PLANNING AND SCHEDULING	2-10
2.5	GENERAL TEST OBJECTIVES	2-12
2.6	TEST REQUIREMENTS	2-13
2.7	TEST PROCEDURES	2-15
2.8	GROUND SUPPORT EQUIPMENT	2-27
2.9	FACILITIES	2-33
2.10	DATA AND REPORT REQUIREMENTS	2-36
2.11	SYSTEMS TEST	2-45
	APPENDIX A - GLOSSARY OF TERMS	A-1

LIST OF ILLUSTRATIONS

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1-1	General Checkout Flow	1-2
2-1	General Checkout Flow	2-5
2-2	Manufacturing Checkout Flow for an Assembled Stage	2-6
2-3	Bar Chart-Checkout Flow of an Assembled Stage	2-7
2-4	Checkout Documentation Flow	2-11
2-5	Mechanical System Schematic	2-17
2-6	Typical Automated Test Sequence Diagram	2-20
2-7	Networks Functional Test, Part 2	2-21
2-8	Networks Functional Test, Subroutine 1	2-22
2-9	Test Procedure Format	2-23
2-10	Test Data Sheet Format	2-25
2-11	Stage Checkout Complex	2-31
2-12	Sample Test Conductor's Log	2-44
2-13	Manufacturing Checkout Flow for an Assembled Stage	2-46

STAGE CHECKOUT PLAN

1.0 INTRODUCTION AND SCOPE

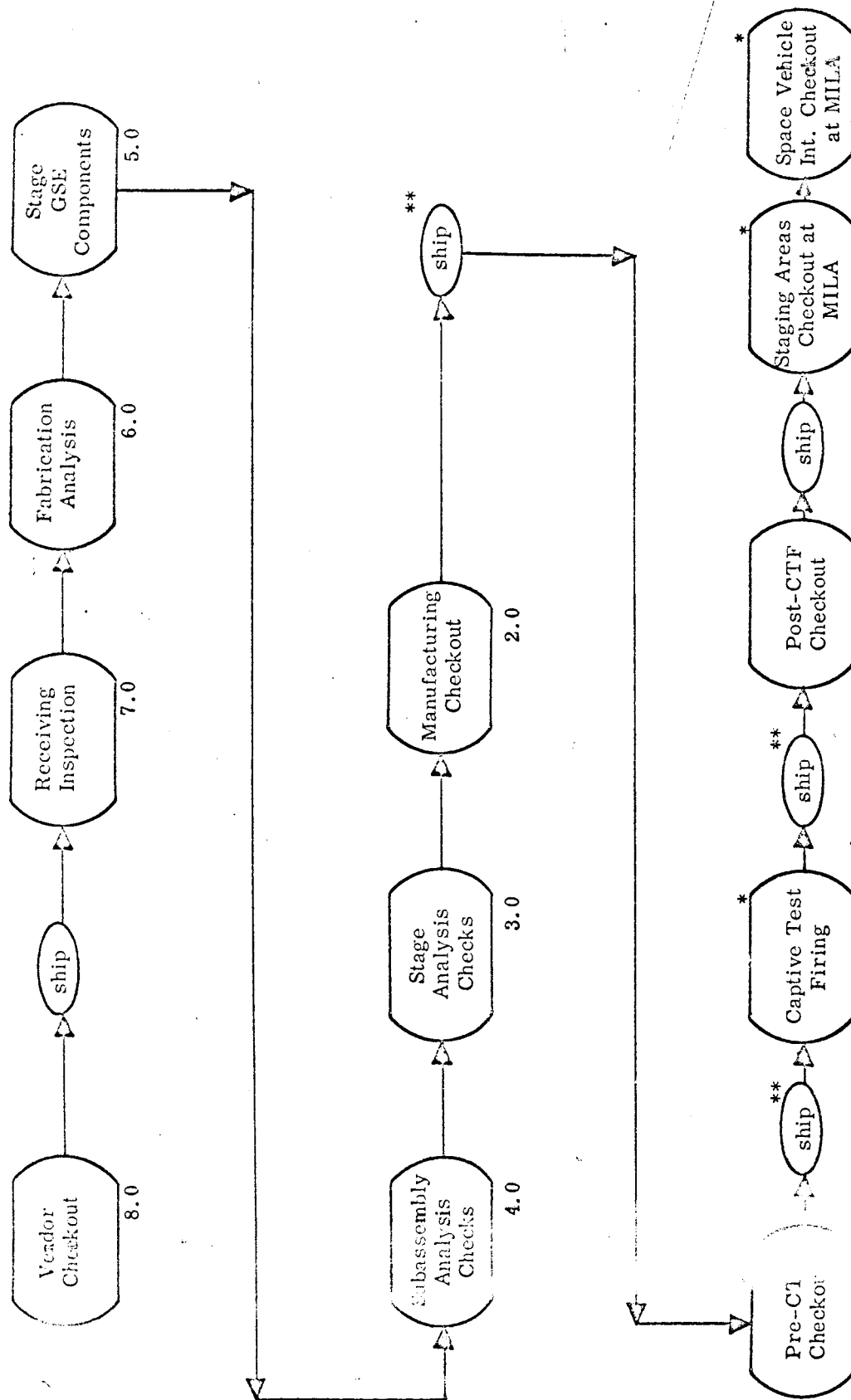
1.1 GENERAL

This plan states the philosophy, requirements, documentation, planning, and equipment descriptions for the checkout of all stages of a launch vehicle. Also presented are those vendor checkout and receiving inspection procedures vital to assurance of quality of parts and materials. The documentation in this plan includes schematic drawings, reports, and procedures: these are essential elements of the checkout program. This plan is oriented to the checkout operations necessary before assembly, during assembly, after assembly, before captive test firing, and after captive test firing; this plan is predicated on broad planning for integration of all elements of the checkout program and scheduling of events. Included in this plan are those guides associated with checkout operations performed on all stages of a launch vehicle or on any component part intended for installation on any stage.

The scope of this plan is in seven parts; each part denotes a major milestone. Each milestone is itemized in Figure 1-1. Three additional milestones (beyond the scope of this plan) are listed to indicate that the checkout performed at the launch site will influence the checkout procedures, checkout equipment, data processing procedures, data acquisition equipment, and software development for other phases of checkout. The plan covers these phases of assembly:

- a. Receiving inspection.
- b. Fabrication analysis.
- c. Components checkout.
- d. Subassembly.
- e. Stage analysis.

These phases are absolutely essential to the total checkout program. They are programmed into the assembly at convenient points; yet, in the interest of efficiency, they receive the same emphasis and consideration as the final manufacturing checkout in determining the acceptability of the stage.



* Not within the scope of this document.

** Stage not to be shipped in some instances.

*** The completion of this checkout will be determined by the procuring activity.

Figure 1-1. General Checkout Flow

After the stage has been completely assembled it is subjected to manufacturing checkout. Manufacturing checkout provides assurance that the stage satisfies design objectives and is ready for shipment to the static test facility.

After arrival at the captive test site, it may be necessary to repeat some or all of the stage analysis checks and manufacturing checkout. This will be determined by various factors, some of which are the distance traveled, the mode of transportation, etc. A post-static checkout must be run subsequent to the static test, even if the static test is determined to be successful. Experience has shown that failures occur at cutoff; these failures cannot be detected by evaluation of the test data. Other failures may be undetected because it is impracticable to instrument all parameters. Also, it is necessary to determine the effect of the captive test firing on systems that were inactive during the test. After completion of this checkout, the stage will normally be shipped to the launch site.

Captive test firing operations are not within the scope of this plan. This plan is based on existing technology and considerable experience, but it is not necessarily exhaustive. The user is encouraged to submit to the procuring activity for consideration all new methods and new perspectives of old methods found. The guidelines presented herein shall form the basis for development of the end-item test plan; however, the user may find that one or more requirements are impracticable or unnecessary. Too, it may happen that the user will conclude that one or more requirements have been overlooked. In such cases, the user shall submit to the procuring activity a request for deviation. In no instance shall the user omit any requirement until he has received written approval from the procuring activity.

1.2 REFERENCED DOCUMENTS

The documents listed herein are referenced for information purposes:

1. Data Submittal Documentation, Contractor Preparation of, Standard for, MSFC-STD-263, 9 November 1962.
2. Quality Assurance Provisions for Inspection Agencies, NPC 200-1, April 1962.
3. Quality Assurance Provisions for Space System Contractors, NPC 200-2, 20 April 1962.
4. Inspection System Provisions for Suppliers of Space Materials, Parts, Components and Services, NPA 200-3, 20 April 1962.
5. MSFC Automation Plan

2.0 ASSEMBLED STAGE CHECKOUT

2.1 INTRODUCTION

This section provides the basic philosophy, guidelines, criteria, and requirements for checkout of the assembled stage prior to acceptance by the procuring activity. A checkout philosophy based on factors such as design objectives, reliability requirements, experience, mission requirements, and complexity of the assembled stage lead to the establishment of the test objectives.

Test requirements include the parameters which would have to be measured in order to fulfill the objectives. Also, they include the general personnel requirements, and a recognition for the need of checkout equipment, data acquisition equipment, and test facilities.

Under analysis, the stage is divided into various systems and subsystems which perform separate, as well as integral, functions. Then, tests are devised to measure the functions which must be verified in order to determine that the system satisfies its design objectives. Following the building-block concept through the individual subsystem and system test requirements, the over-all systems tests are devised. These tests are devised in consideration of mission requirements and systems synthesis. Then, the objectives, test requirements, parameters, etc., of these subsystem and system tests are established in logical sequence. These are described in Section 2.11. After these detailed test requirements have been established, the test equipment and facilities can be described. Requirements for test equipment and facilities will be found in Sections 2.8 and 2.9, respectively.

Adequate communication of information between various organizational components has been a major problem in both industry and government. The section on documentation, Section 2.10, attempts to reduce this problem by discussing the reports and other data which will be required by the procuring activity.

Section 2.4, Program Planning and Scheduling, describes the various charts and schedules that should be included in a test program, as well as the time required to complete various milestones. The section contains a functional flow diagram and a bar graph of the various checkouts which are described in Section 2.11.

Section 2.0 of the plan is concluded with a description of the simulated flight test. Successful attainment of the intent of the objectives of all tests preliminary to the simulated flight test should result in this test being performed without any delay or deviations. Successful completion of this test shall be a prerequisite to the delivery of the stage to the procuring activity.

2.2 SCOPE

This section is applicable to all checkout performed on an assembled stage from the completion of stage analysis until completion of the post-CTF checkout, with the exception of the captive test firing. It includes the checkouts shown in Figure 2-2.

2.3 GENERAL GUIDELINES

The general guidelines in this section which form the MSFC checkout philosophy have been implemented in other checkout programs and differ here only in their application. They are described as they apply to an integrated checkout complex.

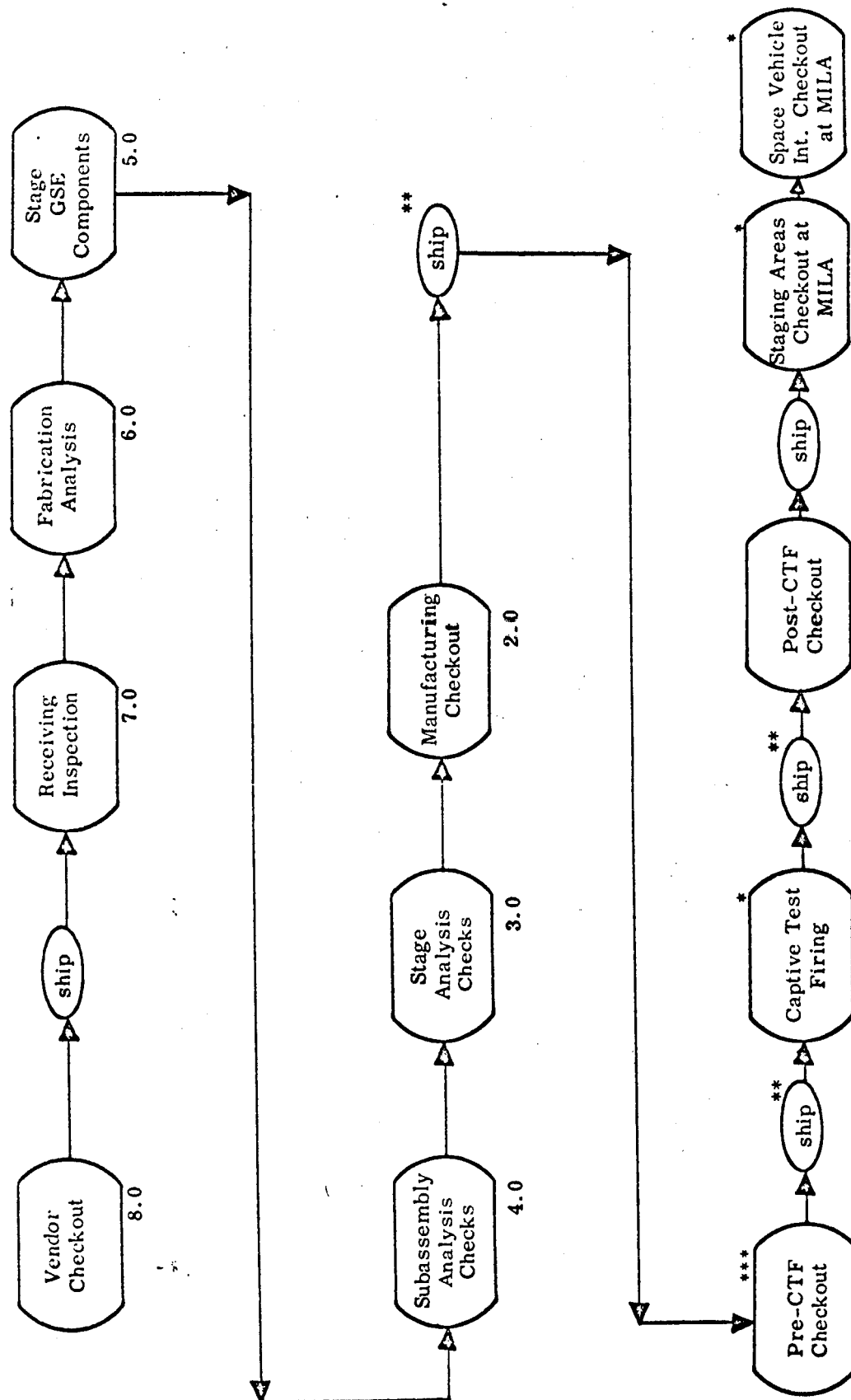
The checkout flow should follow a logical, well planned sequence that permits adequate testing of each component and/or system with a minimum of duplication, and with the most efficient use of manpower, equipment, and facilities. Figure 2-1 is an example of an acceptable checkout plan. Figures 2-2 and 2-3 provide illustrations of checkout flow diagrams.

The building-block principle of testing shall be utilized. This means that components are tested individually before they are required to perform in subsystems, and subsystems are tested individually before they are required to perform in systems. In this manner, problems encountered in an item under test are detected and located with a minimum of effect on units which interface with it in the next higher assembly. This reduces the operating time on the units, increases efficiency, and forms the basis for a schedule which can be more easily met.

The stage checkout operation will be integrated to utilize the checkout time more efficiently and facilities more effectively. All testing will be accomplished in a logical sequence and the test results recorded in a format meaningful to future testing. Testing should be planned to accommodate failures and fault isolation routines without interrupting all checkout operations.

The checkout operation should have its own integrity. It should be accomplished in a separate checkout area in which working conditions, as well as access to the area, are strictly controlled. No assembly work should be performed on the item which is under test except rework which is scheduled on a non-interference basis. Substitution will be used as sparingly as possible and primarily for reasons of safety. No simulated flight hardware will be used during checkout except as required for safety reasons. Unnecessary interruptions of the test proceedings should be avoided.

The checkout system should be developed from concepts based on the most versatile selection of manual and automatic systems to arrive at the optimum balance between man and machine. The end result of automation should be equal to or better than the end result of alternate methods.

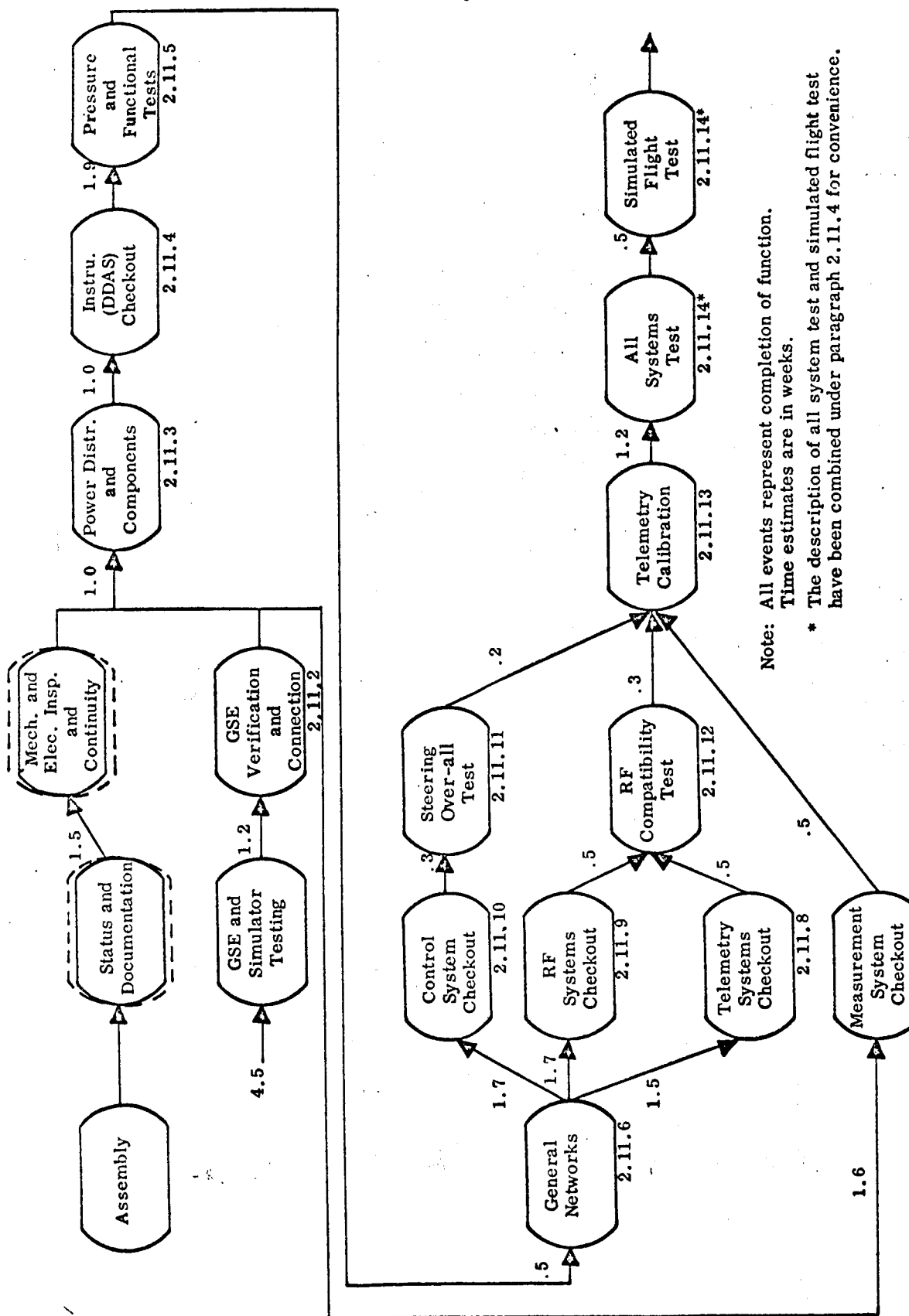


* Not within the scope of this document.

** Stage may not be shipped in some instances.

*** The extent of this checkout will be determined by the procuring activity.

Figure 2-1. General Checkout Flow



Note: All events represent completion of function.
Time estimates are in weeks.

* The description of all system test and simulated flight test have been combined under paragraph 2.11.4 for convenience.

Figure 2-2. Manufacturing Checkout Flow for an Assembled Stage

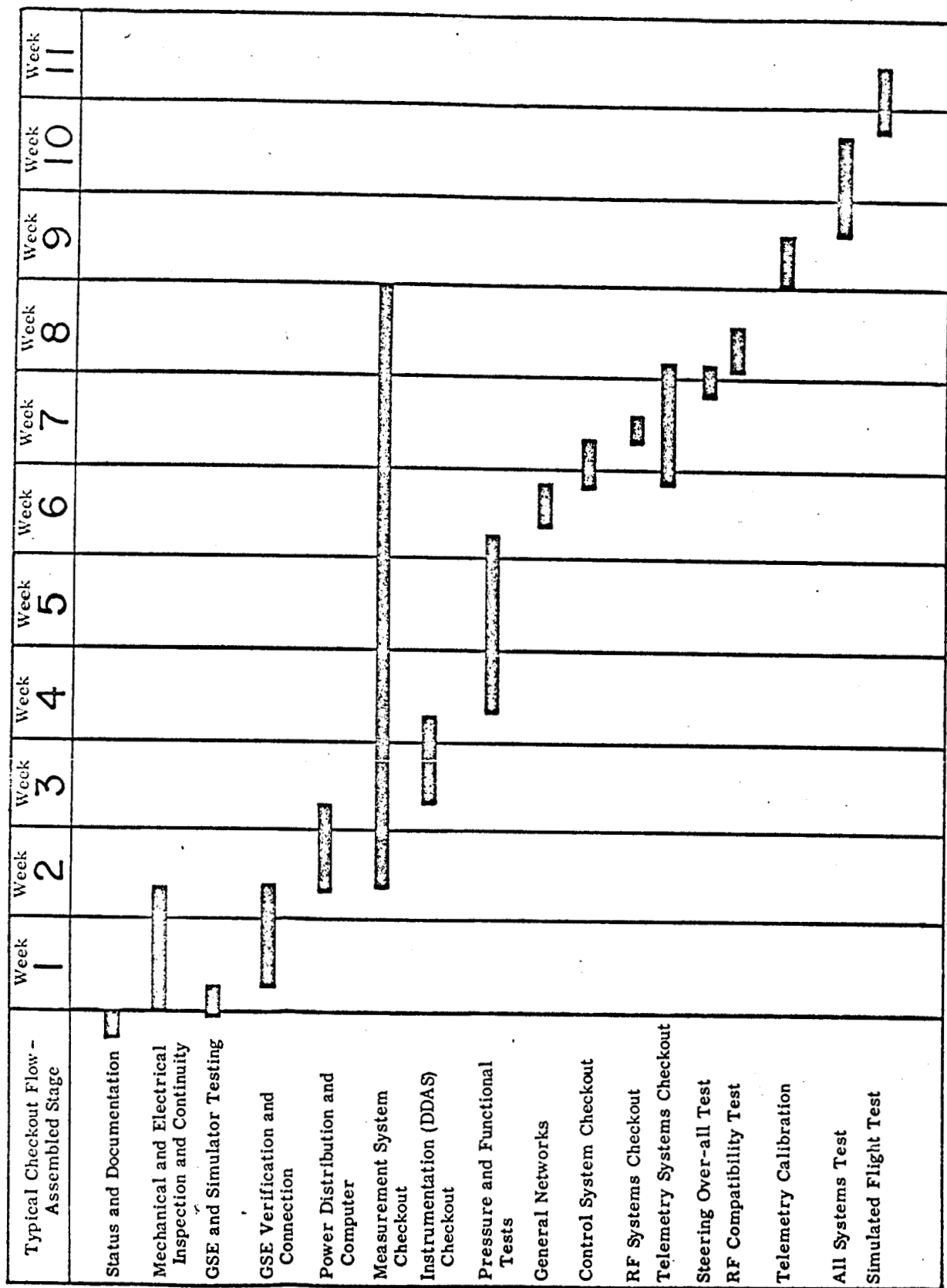


Figure 2-3. Bar Chart-Checkout Flow of an Assembled Stage

The organization responsible for stage checkout should have trained, highly skilled personnel who thoroughly understand the test specimen and should perform independently of the design and manufacturing elements. They should establish test criteria derived from design specifications and design objectives and should be responsible for accepting the checkout results.

A test conductor engineer with a technical understanding of the test equipment, the item under test, and the test procedures shall be assigned the responsibility for all testing. He must be a participant in the checkout and be available at all times. He shall control access of personnel to the test area, which is normally limited to the test conductor and his required assistants. The test conductor should be cognizant of management policies and should be responsible for the checkout schedule. Checkout engineers who specialize in the various subsystems should be available to assist the test conductor at all times.

The status and anticipated progress of the test procedures should be reported at regular intervals, by the test conductor, to all testing personnel.

No acceptance test shall be performed except by use of procedures previously approved and signed by the procuring activity.

An organized data processing plan shall be developed and implemented. This plan should insure that all required data is processed and delivered to cognizant organizations.

A complete and accurate log of all the significant events which occur during the testing should be prepared each day and signed by the test conductor. It should contain a summary of the events of the day, such as problems, solutions, progress, etc.

Test equipment and hardware under test should incorporate fail-safe provisions so that it returns to a safe condition in the event of power failure or other emergency.

Stage checkout must demonstrate compatibility of all systems. No subsystem vendor checkout data will be accepted in lieu of stage acceptance test results except for those tests which may be impractical to perform for safety reasons and/or because of expendable items.

Replacement or rework of parts shall require that appropriate tests be re-run in order to verify that the new part is compatible with and meets the requirements of the system.

A comprehensive checkout program will determine that no problems result from interaction of systems or subsystems, in addition to verifying the satisfactory operation of the individual system or subsystem.

Standardization of equipment, procedures, and techniques should be accomplished where it is practical and where it does not compromise objectives.

2.4 PROGRAM PLANNING AND SCHEDULING

2.4.1 Introduction

To implement the requirements of a test plan, major milestones should be established and scheduled. These major milestones will facilitate the establishment of the broad objectives and requirements. Detailed planning and scheduling will be conducted concurrently with the establishment of requirements and specifications. Charts and schedules will be prepared, such as the summary type charts shown in this section. Detailed "shread outs" (or breakdowns) of these charts in real time should also be made; however, it is not practical to include examples of these in this document.

2.4.2 Major Checkout Milestones

Figure 2-1 shows the major checkout milestones which are within the scope of this plan.

2.4.3 Manufacturing Checkout Flow

Figure 2-2 shows the events that make up the manufacturing checkout block shown on Figure 2-1. It presents an example of the sequence of events, together with the time scheduled to accomplish these operations. Detailed examination and planning is required to determine the proper sequence and to determine which operations can parallel each other.

2.4.4 Manufacturing Checkout Bar Chart

The bar chart shown in Figure 2-3 is used to illustrate parallel and series test operations as well as the planned time to perform the operations. This type of chart is more readily oriented to the calendar and enables the planner to visualize the scheduling problems.

2.4.5 Checkout Documentation Schedule

Figure 2-4 shows the time and event relationship between the various procedures, specifications, and other documents which must be time-phased into the hardware and test equipment delivery schedule. The time sequence of events enables the planner to detect critical areas so that proper emphasis can be applied to insure that the end-item delivery dates are met.

2.5 GENERAL TEST OBJECTIVES

The test objective defines the purpose for which a test is performed. Any test procedure or test operation must assure that the test objective has been accomplished. The readout of the correct parameter, in itself, does not necessarily constitute compliance with the test objectives. The intent of the objective must also be accomplished. This requires that the person conducting the test understands the item under test and the test equipment thoroughly.

The objective of each test which is to be performed should be clearly stated in the over-all test plan and in each test procedure. Test objectives are formulated from analyses of the design objectives, design intent, and past experience with similar systems. The test conductor is responsible to insure not only that each test is performed, but also that the test objectives are accomplished.

The objectives of assembled stage checkout are to demonstrate the operational suitability of the stage. Other objectives of this checkout are as follows:

- a. To demonstrate the adequacy of the design.
- b. To verify that the hardware fulfills quality and design requirements.
- c. To gain confidence that the hardware will satisfy mission requirements by furnishing data for reliability assessment.
- d. To discover hardware defects and discrepancies so that timely corrective action can be initiated.
- e. To reduce the cost of developing an operational stage by eliminating many problems prior to the flight test and thereby improving the probability of success of the flight test.

The detailed test objectives that must be satisfied for each checkout which is performed under this plan are outlined in Section 2.11 with their associated checkout.

2.6 TEST REQUIREMENTS

Test requirements are generated in an attempt to insure that the test objectives are accomplished in a manner which is safe, efficient, and adequately documented. For example, by specifying the parameters which have to be recorded and the specifications of the data acquisition system which is used, the test engineer is more certain that he will obtain the data that he needs to evaluate his system. Test requirements may be prepared for the purpose of describing all known equipment, data, personnel, conditions, and any other resources that must be applied in order to accomplish the intent of the objectives. Failure to describe the requirements adequately could result in testing that does not accomplish the objectives. This in turn would lead to a re-run of the test. The re-run can be avoided by studying the objectives and applying the equipment and facility, personnel, and other resources in an efficient manner by listing the requirements for this item in advance of the test.

Some of the requirements generally considered are listed below:

- a. List of parameters which should be measured to determine if the objectives have been accomplished:
 - Accuracy of measurements.
 - Type of measurements.
 - Range of measurements.
 - Frequency response of measurements.
- b. Number of test points or measurements to be made.
- c. Test stimuli and excitation requirements for performing the test.
- d. Quantity of data and the method of processing data acquired during the test.
- e. Type and configuration of the test equipment which is required in order to accomplish the objectives.
- f. Number of test personnel which are required to perform the test.
- g. Type of test personnel.
- h. Confidence level which must be obtained in both the test equipment and the vehicle under test.
- i. Time interval available for accomplishing the test.

Test requirements should be presented in sufficient detail to insure that all objectives are accomplished. An example of some of the items that are specified in test procedures and plans have been included in paragraph 2.11.2.

Detailed requirements include such things as limitations to insure that design limits are not exceeded, requirements to prevent contamination, requirements to provide adequate safety, etc. Carefully prepared detailed requirements result in greater efficiency and added protection to the item under test.

2.7 TEST PROCEDURES

2.7.1 General Requirements

Test and checkout procedures shall be prepared for all levels of testing on the assembled stage. The contractor shall furnish a minimum number of copies (to be determined by the procuring activity) at least six weeks prior to the commencement of any test. The contractor shall furnish a like number of copies of all applicable documentation listed in the test procedure. If, at the time of submittal, the contractor determines that the procuring activity is in possession of the applicable documentation, the latter requirement is waived.

2.7.2 Test Procedure Description

2.7.2.1 Test Procedure Title Page

These test procedures shall contain, as a minimum requirement, the following information:

- a. Test procedure identification (title page).
- b. Table of contents.
- c. A list of applicable documentation.
- d. Test equipment list.
- e. The objective of each test.
- f. A list of the flight article or articles under test.
- g. A functional description of each test.
- h. Test connection chart.
- i. A test sequence diagram designating the order in which the test is to be performed (for computer-controlled tests).
- j. A test flow chart (for the computer-controlled tests).
- k. Preparatory steps, including any precautions or warnings, or notes on the environment in which the tests are performed.
- l. The test data or results to be recorded.
- m. The format of the test data sheet.

The test procedure title page shall contain, as a minimum requirement, the following information:

- a. Name of test procedure.
- b. Stage under test.
- c. System and subsystem under test.
- d. Test procedure number and/or drawing.
- e. Procuring activity test procedure approval block.
- f. Test conductor block.
- g. Procuring agency test approval block.
- h. Date of approval block.

2.7.2.2 Table of Contents

A table of contents shall be included in the test procedure. In addition to listing the major section headings of paragraph 2.7.1, it should list the title and first page number of each test segment.

2.7.2.3 Applicable Documentation

Applicable documentation shall include, but not be limited to, the latest revisions of the following:

- a. Schematics of the article under test (electrical and/or mechanical as required; e.g., Figure 2-5).
- b. Schematics of the participating GSE (electrical and/or mechanical as required).
- c. Interconnection diagrams, within the stage, within the GSE, and between the two (electrical and/or mechanical, as required).
- d. Wiring lists for sequence recorders.

2.7.2.4 Test Equipment List

The test equipment list will show all the major elements required to support the test. The equipment, or groups of equipment listed, will be the same level as shown on the test interconnection diagram. For example, for a power distribution test the list would include:

- a. Computer complex.
- b. Electrical test station.
- c. Stage/ground interface distributor.

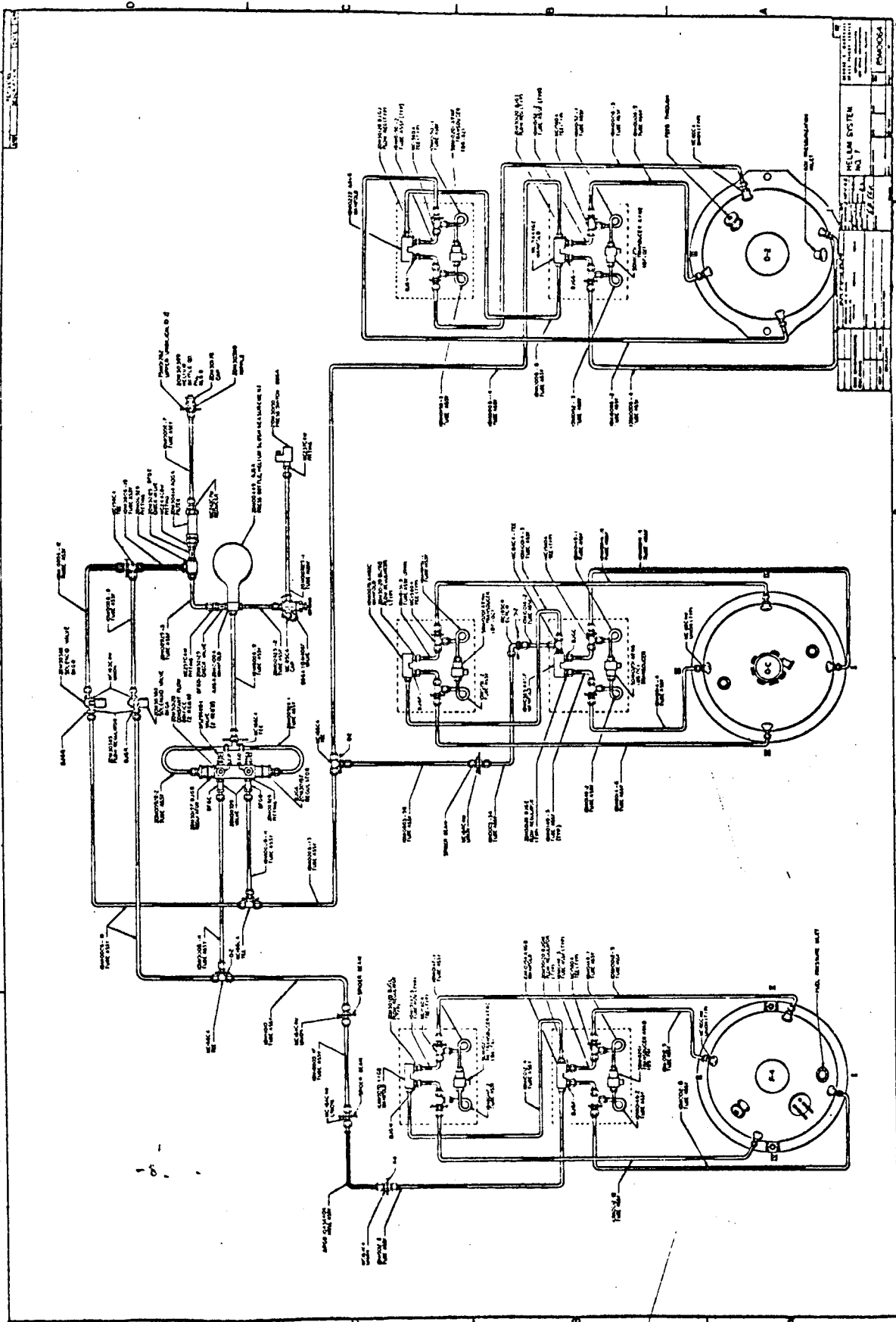


Figure 2-5. Mechanical System Schematic

- d. Data systems test station.
- e. Ground power.
- f. Test conductor's console.

2.7.2.5 Test Objectives

The purpose or purposes for which the test is being performed shall be clearly stated. The successful accomplishment of the test requires that this objective be satisfied.

2.7.2.6 Articles Under Test

The test procedure shall contain a listing of the articles under test. This will assure the readiness of all elements required to participate.

2.7.2.7 Functional Description

A functional description of the test shall be included in the test procedure. This description shall be in narrative form and shall contain specifics of how the test will be performed.

2.7.2.8 Test Connection Chart

A chart showing all special test connections shall be included. This chart will take the form of a cable running list.

2.7.2.9 Test Sequence Diagram

A test sequence diagram shall be prepared as a part of each automated test procedure. This diagram shall show the major steps in the sequence of tests associated with an automated checkout. An example of an acceptable format for the test sequence diagram is shown in Figure 2-6.

2.7.2.10 Automated Test Flow Charts

A set of flow charts shall be prepared as a part of each automated test procedure. These charts shall include a master flow chart that shows the entries, routines and subroutines, breakpoints, and exits for each program that makes up the complete automated checkout sequence; flow

charts of each routine and subroutine; other programming levels used by the computer; and a detailed flow chart of each program segment utilized in the automated test sequence.

Examples of the minimum information to be shown on each of these charts are given in Figures 2-7 and 2-8.

2.7.2.11 List of Test Personnel

The list shall show the number, skill level, and duties of all required test personnel. Key personnel (test conductor and specialists) shall be identified by name.

2.7.2.12 Preparatory Steps

This category shall include a list of all steps which must be accomplished prior to commencement of testing. This includes special test connections, safety announcements, start recorders, etc. These functions shall be grouped under the heading of the test element responsible for their accomplishment.

2.7.2.13 Test Procedures

This section shall contain the actual steps in the test. The following shall be considered as the minimum information required in the section:

- a. Step number.
- b. Input test point.
- c. Input stimulus.
- d. Action being performed.
- e. Response test point.
- f. Limits of response.
- g. No-go action.
- h. Recorder number.
- i. A column for remarks (the response can be identified in this column).

Figure 2-9 shows an acceptable format for a test procedure sheet.

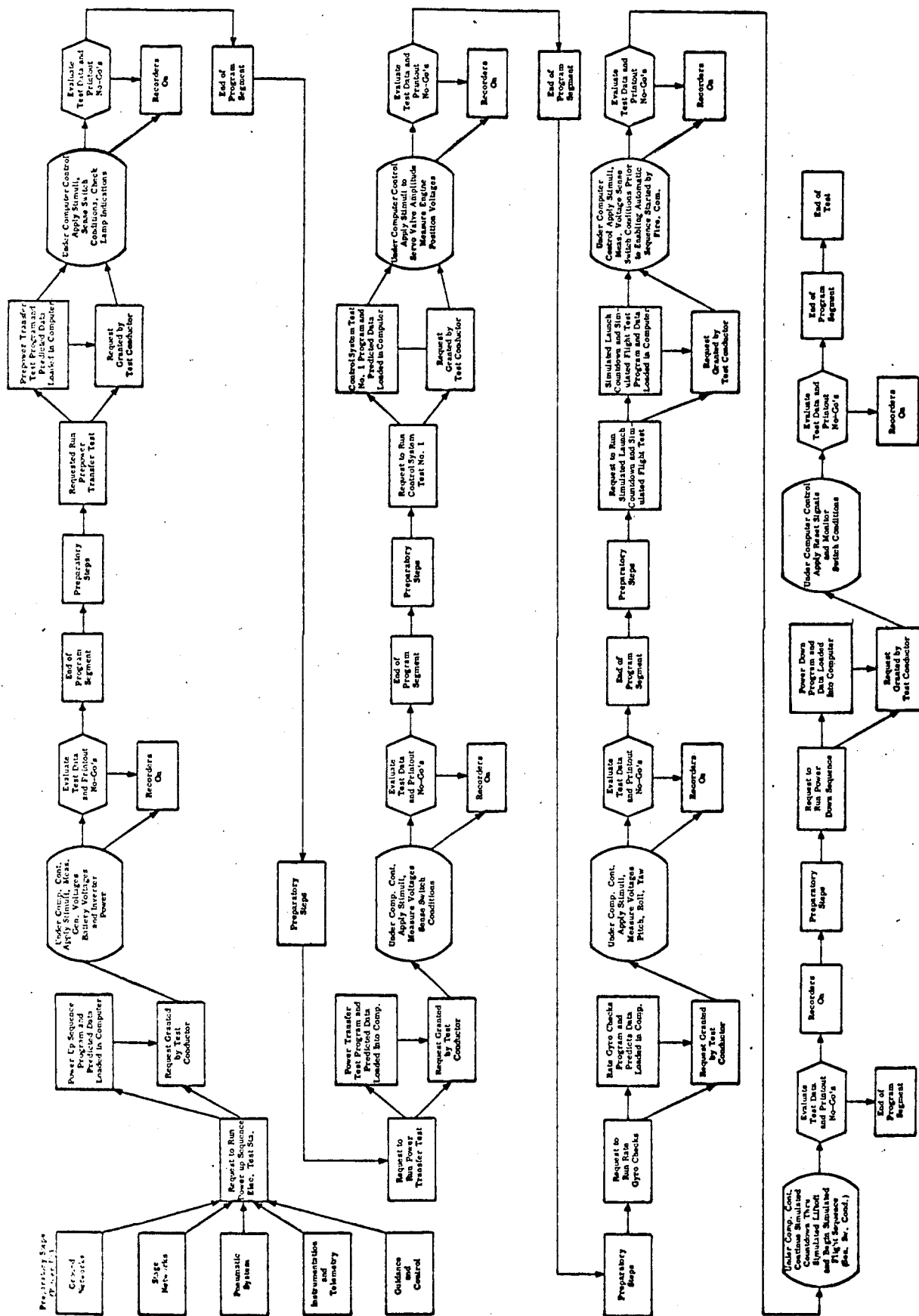


Figure 2-6. Typical Automated Test Sequence Diagram

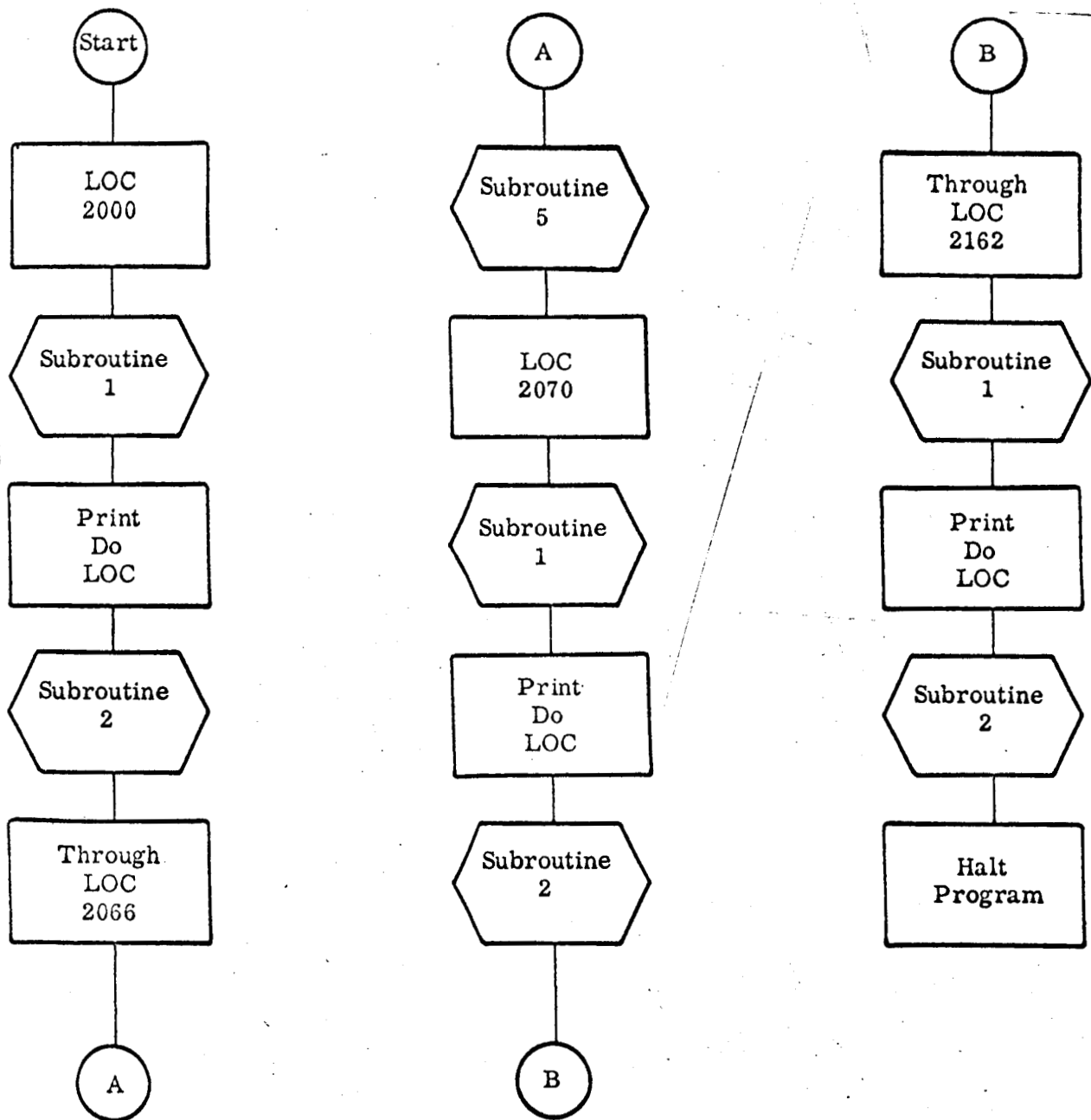


Figure 2-7. Networks Functional Test, Part 2

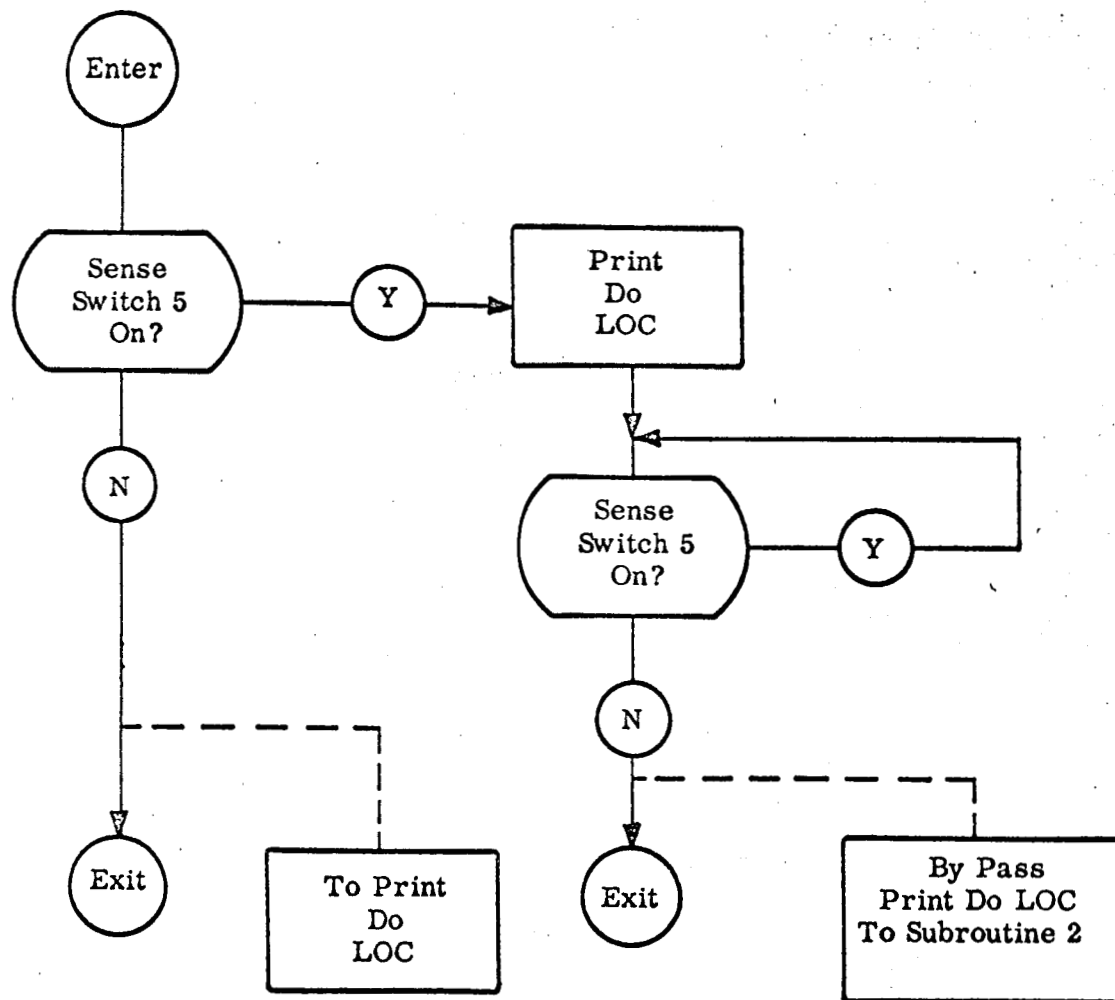


Figure 2-8. Networks Functional Test, Subroutine 1

THE SPECIFIC STEP OF THE PARTICULAR SEGMENT	STEP		
THE RELAY NUMBER WHICH IS USED TO APPLY STIMULI TO THE STAGE	RELAY NO		
CONDITION OF RELAY: E-ENERGIZED, R-RELEASE	C		
THE MINIMUM TIME ELAPSE AFTER THE OPERATION OF RELAY BEFORE SAMPLING OF THE MEASURAND COMMENCES	MIN		
THE MAXIMUM OPERATION TIME OF THE RELAY AND THE TIME AT WHICH THE MEASURAND SAMPLING IS CONCLUDED	MAX		
PERIODICITY - THE FREQUENCY RATE AT WHICH THE MEASURAND IS SAMPLED. LETTER "O" DENOTES CONTINUOUSLY-NUMERICALLY STATED VALUES IN MILLISECONDS	PER		
RELAY NUMBER OR CROSS BAR SWITCH POSITION. CROSS BAR LOCATION GIVEN IN TERMS OF THREE DIGITS: SELECT, HOLD, AND LEVEL	RELAY OR X-BAR		
DISCRETE- "O" DENOTES ZERO VOLTS, ONE INDICATES LEVEL OF 28 VOLTS	D		
PRINT	P		
ALARM	A		
RECYCLE	R		
CONDITION - ACTUAL ANALOG VALUE OF VOLTAGE	COND		
THE PERMISSABLE VARIATION LIMITS OF THE MEASURAND BEING SENSED (REQUISITE FOR AN IN-TOLERANCE CONDITION)	LIMITS		
DISPLAY	D		
PRINT	P		
EVENT RECORDER PIN NUMBER	E.R. NO		
IDENTIFICATION OF EQUIPMENT BEING TESTED AND/OR TEST BEING PERFORMED	REMARKS		

Figure 2-9. Test Procedure Format

2.7.2.14 Test Data Format

2.7.2.14.1 Manual

An example of an acceptable format for the presentation of test data is shown in Figure 2-10. This format includes an identifying code, component identification, component part number, test data instruction, specification (tolerances), and the test data results. These data sheets are used for the test conductor and/or systems engineer, along with the test procedures, during the assembled stage checkout. It should be pointed out that the results column should appear blank prior to performance of the checkout. This column shall be used to record data results as the test progresses.

The identifying code shall include, as a minimum requirement, a code for each of the following:

- a. An indication of the action to be taken.
- b. The stage being tested.
- c. The test (prestatic or post-static).
- d. The system being tested.
- e. The type of component being tested.
- f. The medium handled by the component.
- g. The medium by which the component is operated.
- h. The individual major component.
- i. The function to be performed on the component.
- j. The defect and rework of a component.

2.7.2.14.2 Automated

The test data format shall include, as a minimum requirement, an identifying code, identification of the component subsystem or system being tested, the test condition or nominal value, and the measurement tolerances allowable in the results of the test.

GN2 CONTROL PRESSURE SYSTEM		PROCEDURE	INDICATION/SPEC	RESULTS
STEP NR				
15	REDUCE PRESS TO 2000 PSIG AND LEAK CHECK THE FOLLOWING.	ALL HI PRESS CONNECTIONS AND COMPONENTS SPHERE FILL AND VENT VLV SEAT LEAKAGE BKDM.NF	NAL 5.0 SCIM MAL	
16	VENT HIGH PRESS FILL LINE TO ZERO PSIG AND REMOVE FROM QUICK DISCONNECT			
17	LEAK CHECK AT QUICK DISCONNECT FOR REVERSE SEAT LEAKAGE PAST GN2 CONTROL HP CHECK VLV BFEW.NF		1.0 SCIM MAL	
18	RECONNECT HIGH PRESS FILL LINE AND PRESSURIZE TO 2000 PSIG.			
19	ADJUST CONTROL REG TO 750 +/- 15 PSIG AND CHECK REGULATOR PRESSURE BUILD-UP	BJDA.CD	20 PSIG MAX ALLOWABLE	
20	CHECK REGULATOR BLEEDER PLUG FLOW RATES.			
	REGULATED PRESSURE BLEED	BJDA.MC	75 +/- 25 SCIM MAL	
	PILOT BLEED	BJDA.MB	150 +/- 50 SCIM MAL	
	MANUAL BLEED VALVE	BJDA.NT	2.0 SCIM MAL	
	REFERENCE PRESS SEAT LEAKAGE AT KNOB	BJDA.NV	10.0 SCIM MAL	
	INTERNAL RELIEF VALVE SEAT LEAKAGE	BJDA.NU	10.0 SCIM MAL	
21	CHECK MANIFOLD RELIEF VALVE BLEED RATES			
	SIX MAIN VENT HOLES	BLDB.NW	2.0 SCIM MAL	
	1/4 INCH VENT HOLES	BLDB.NX	2.0 SCIM MAL	
22	LEAK CHECK ALL 750 PSIG CONTROL LINES TO SOL. VLVs		NAL	
23	CHECK LEAKAGE PAST THE FOLLOWING CONTROL VLV SEATS			
	LOX VENT AND NR 1 RLF VLV CONTROL VLV BKDQ.NE		5.0 SCIM MAL	
	CALORIMETER PURGE CONTROL VALVE BKDA.NE		5.0 SCIM MAL	

Figure 2-10, Test Data Sheet Format

All test response and measurement data shall be read in and stored in the designated computer memory location in accordance with the programmed instructions as the automated test progresses. A digital word containing an address, a command, and the data bits representing the measurement, as described in the MSFC Automation Plan, shall be utilized to store each measurement in the computer memory.

The computer shall perform all test data evaluations in accordance with the programmed instructions. The results of the test data evaluation shall be formatted and transferred to the appropriate test station or test conductor for display purposes.

At the completion of a test program segment, the computer shall be required to format and output all measurement data and results to external data recording equipment for use in an off-line data processing system. The computer shall output this data in a format such as IBM 729 Mod II and Mod IV binary coded decimal, as discussed in the MSFC Automation Plan.

The test data shall also include any analog measurements or any interlocking signals that may be brought from the stage via hardwires.

2.8 GROUND SUPPORT EQUIPMENT

2.8.1 Introduction

In support of stage checkout, the ground support equipment is required to supply the following:

- a. AC and dc electrical power.
- b. Pneumatic and hydraulic power.
- c. Control of stage and ground electrical networks and pneumatic systems.
- d. Electrical and mechanical test stimuli.
- e. Response monitoring and measuring.
- f. Test data recording.
- g. Test data evaluation and fault isolation.

The details of the equipment chosen to supply the above items and functions can vary considerably. There is one general question, however, which must be resolved before these details can be considered: that is whether to implement stage checkout manually or automatically. One fact, above all, makes the use of a computer for Saturn stage checkout almost mandatory: that is the very large number of test points associated with a stage, and the speed in which these test points are presented to the checkout equipment. The ability of a computer to accept this large quantity of rapidly presented data, compare it to predetermined tolerances, and print out results in a minimum of time with great accuracy makes it a powerful checkout tool.

The requirement for computer-controlled checkout does not require that every test operation be performed automatically. There are many test operations where automation is not technically or economically feasible. Many mechanical functions are in this category. Each test operation must be assessed on its own merits as to whether or not it should be automated. The main criteria are the technical and economical feasibility and the effect on the reliability of the system. No test operation should be automated if it is determined that doing so reduces system reliability.

2.8.2 General Requirement

As stated previously, the details of the equipment chosen to perform the ground support functions may vary considerably between different organizations for many reasons. Not the least of these reasons is experience. The experience gained by the procuring activity through many years of testing large boosters gives rise to the following general requirements for ground support equipment:

- a. The test complex shall be integrated to the extent that the duplication of functions and equipment is minimized. An example of this occurs when different stations require the same stage function or control. That function or control shall be provided in the one station that is the most logical. This requirement shall not eliminate redundancy when this redundancy is required to meet reliability goals.
- b. All test operations shall be performed by or under the cognizance of the central computer complex. This means that test operations will be monitored by the computer, and whenever practical, the test results will be inserted in the computer memory even when it is decided to perform a test operation manually. This requirement takes maximum advantage of the computer as a data storage facility and minimizes the opportunity for a human error.
- c. A test conductor's console shall be provided. It shall contain the controls and indicators necessary for maintaining responsibility for the stage checkout and coordinating all checkout activities.
- d. Test stations which group functionally similar stage systems shall be provided. These stations shall provide the cognizant system engineers with sufficient data to determine the condition of the system under test. It shall provide the station operator with the capability of calling up subroutines for fault location, etc. It shall also provide the operator a means of local control for manually inserting steps to enable the program to continue.
- e. Functions unique to a particular stage system will be grouped in an appropriate test station. However, the existence of a unique system does not justify the existence of a test station for it alone. In an instance where a system requires only a small quantity of checkout equipment, that equipment will be grouped in an existing test station.

- f. The test complex shall be assembled in modular form. These modules shall, in general, be standard, commercially available items. Unique test complex configurations can then be attained through the use of patchboards, etc.
- g. A manual safeing capability shall be provided. This function shall be controlled by the test station operators. It shall act independently of the computer and perform all of the functions necessary to render the vehicle safe. This requirement specifies that a manual/automatic interface be designed into the stage/ground interface distributor (see paragraph 2.8.3).
- h. A digital event evaluator shall be provided. This unit shall be capable of scanning all discrete stage output lines continuously, recording event changes, and recording the time of these changes. It shall be capable of being programmed to evaluate these events.
- i. A voice intercommunication system which allows the free exchange of information between all test personnel should be provided.
- j. Rigid tubing shall be used to route gases and fluids to the stage wherever practical. This includes routing along work platforms. Flexible hose shall be used to connect the distributors to the work platforms and the work platforms to the stage. All supply and monitoring lines shall be designed for a specific application or test. It shall be labeled and color-coded for the media used or the system tested. Sufficient pneumatic circuits shall be provided so that it is not necessary to change connections during a test.
- k. The emergency vent system shall be an integral part of the pneumatic equipment. It will provide for automatic shutdown of pressure and automatic venting whenever specified test pressures are exceeded. This system will be continuously operated whenever pressure is applied to the stage. Visual and audible devices shall be used to detect actuation of the system. A reset capability will be provided in the system so that reset can be effected after pressure has decayed to within safe limits.
- l. The pneumatic system shall be capable of metering and injecting tracer gases into the pressurizing system to assure proper mixing of the test gases and tracer gases.

- m. Ground cooling equipment shall be provided for those systems that require cooling during periods of extended operation on the ground. The system will be controlled remotely from the electrical test station.

The mechanical support equipment shall consist of hydraulic and pneumatic equipment capable of supplying stimuli to and measuring responses from the stage hydraulic and pneumatic systems. It shall have the capability for local manual control and remote manual and automatic control from the mechanical test station.

It will contain regulators, valves, gages, transducers, pumps, servo regulator modules, relief valves, flowmeters, etc. It should provide for the distribution of data to the digital event evaluation, to the computer, and to the digital data acquisition system.

2.8.3 Stage/Ground Interface

There are certain functions in the ground systems which are an integral portion of the stage circuitry. These functions are sometimes referred to as "relaying," "interlocking," "relay logic," etc. The purpose of these functions is to assure that no switching can be done unless the prerequisites for that switching have been accomplished. The prerequisites are, in general, required for safe operation.

These functions shall be grouped in a separate piece of equipment which provides the stage/test complex interface. The three primary reasons for this interface equipment are:

- a. Critical functions can be hardlined back to the test station to provide a manual safeing capability.
- b. A single rack or group of racks can be identified which adapt the stage to a general-purpose test complex.
- c. Programming is simplified. Changes in stage interlocking or relay logic can generally be made with no effect on the checkout programs unless, of course, the switching sequence is altered.

Figure 2-11 shows a simple block diagram of a stage checkout complex. All of the major equipment groups of a typical test complex are shown.

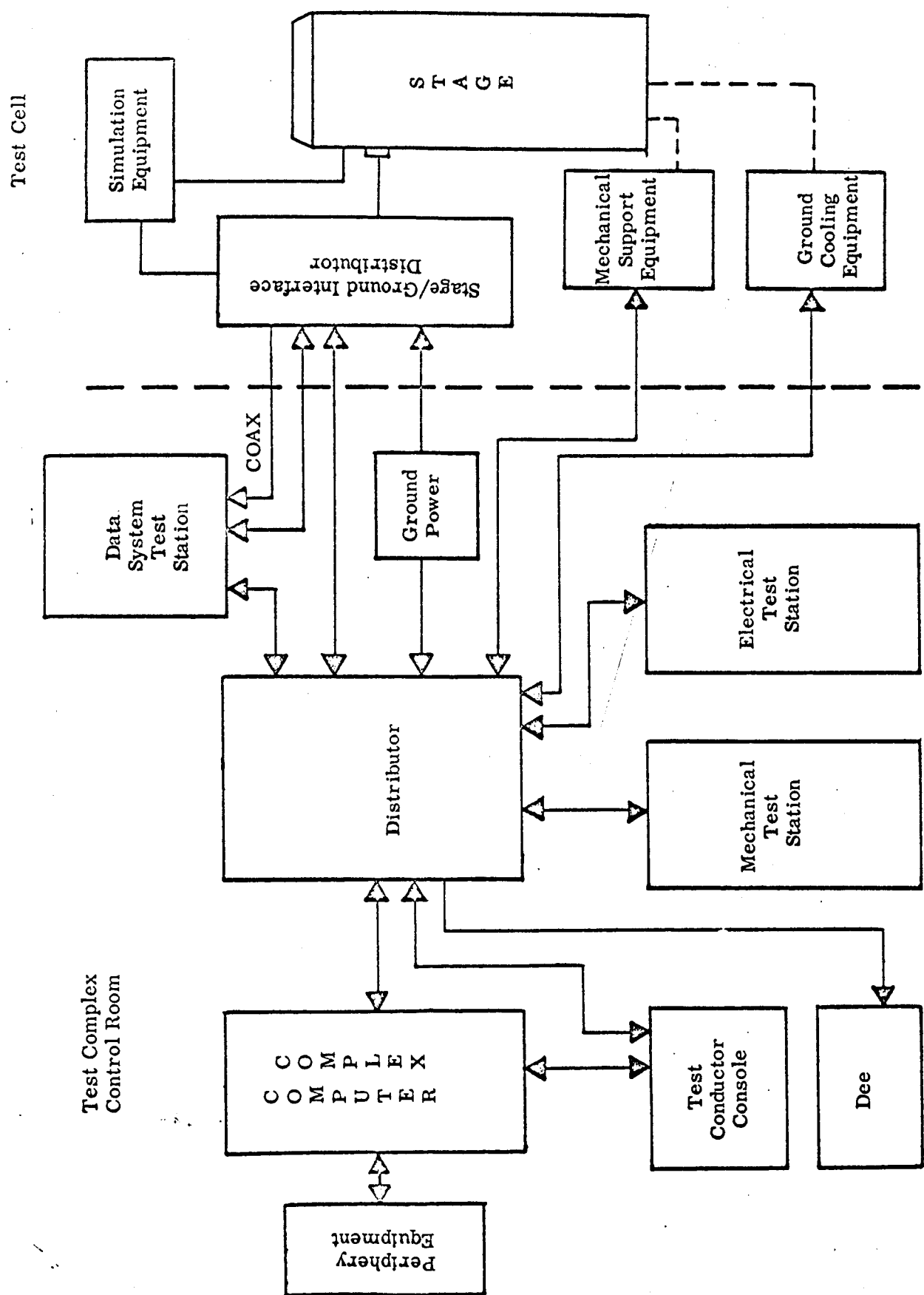


Figure 2-11. Stage Checkout Complex

Within the scope established by this block diagram, the contractor shall submit the following to the procuring activity:

- a. An interconnection diagram showing all of the electrical and mechanical connections.
- b. A description of the operation of the stage checkout complex. This description will be keyed to the checkout program, as described in Section 2.11, so that it will show how the checkout will be accomplished by the complex.
- c. Schematic diagrams of each block on the interconnection diagram. With the schematics, the following shall be submitted:
 - (1) A functional description of the operation of the blocks. This description should include the operation of the block as well as the block operation in the total system.
 - (2) A breakdown of the blocks and a description of the operation of each element in the breakdown.
 - (3) An equipment description to show what equipment is planned to accomplish the functions of 1 and 2 above.
 - (4) A description of the environmental requirements of the equipment.
- d. A complete description of the software associated with the checkout complex, including the approach to checkout programming.

2.9 FACILITIES

Facilities are those ground supporting elements which provide all the necessary accommodations to assist the ground support equipment in performing an adequate checkout of a stage, instrument unit, space capsule, or payload. Facilities will include the complex housing, pads, electrical power, pneumatic and hydraulic power, etc.

The facilities should be designed to fulfill the requirements of the checkout program. This includes providing support for the ground support equipment. The concepts that form the checkout philosophy should also be considered in designing the checkout facility.

The electrical and mechanical facilities requirements described below are minimum requirements.

Two separate commercial power busses shall be provided as the primary power source for the GSE for checkout and launch conditions. They shall be designated as the critical and utility busses, respectively. The commercial critical buss shall be a buss to which is provided a guaranteed power supply by the commercial power company, with absolutely no power interruptions. The simulated flight test during checkout and the launch countdown shall operate on the critical power buss. The commercial utility buss will be the regular commercial power available for the area. All tests except simulated flight and launch countdown shall be conducted on this buss. The computer power supply shall be connected to the commercial critical buss. The primary commercial power supplied on the critical and utility busses shall be transformed to 480/120/208 volts ± 5 percent, three phase, four wire, wye connected, neutral grounded to a unipotential ground, 60 cps ± 0.1 percent.

Battery backup power (24 to 32 volts) will be provided to insure the capability of bringing the stage down to safe conditions regarding pressures, etc., in case of a power failure during checkout or launch countdown. A positive battery, 24 volts dc, shall be impressed across the static power supply busses (approximately 32 volts dc at the supply) at all times during checkout or launch, and will be followed by switching a 32-volt dc battery power on the main dc busses upon static power supply failure. The switching of 32 volts dc on the main dc busses will be accomplished in several milliseconds and will bring the main dc busses from the already existing 24 volts dc up to 32 volts dc.

An adequate number of power outlets shall be conveniently located in all areas where tests will be conducted to facilitate easy access and flexibility of location for all mobile electrical equipment which will be utilized during stage checkout.

Adequate power and RF grounding shall be provided in the checkout area and for all applicable stage and checkout equipment.

Sufficient RF shielding shall be provided on all equipment and in all areas where such areas or equipments would be adversely affected by the RF radiation which will exist in the checkout complex.

Motor-generator sets will be provided as a power source for all equipments which are adversely affected by normal power transients.

Visual indicators and continuous recording devices will be provided to monitor and record important power parameters.

Emergency battery-powered lighting shall be provided in all test and equipment areas.

Ground connections will be checked to insure that there is no difference in potential between grounds.

Personnel access platforms, which also provide mechanical-electrical tie-in to the stage, shall be provided to adequately check out the stage.

Convenience power outlets to support testing shall be provided on the work platforms at all work levels.

Light fixtures for illuminating test areas within the stage shall be fixed permanently to work platforms and/or provided convenient within the stage.

A clean storage area shall be provided in or adjacent to the cell for storage and issuance of all test fixtures and test hoses.

Test media shall flow through a supply system, dryer and filtration system prior to entering the test carts or control panels. Supply bottles, dryer, and filtering system shall provide monitoring points for gas sampling to determine contaminant levels.

Hydraulic pumping stations shall be located outside of the test area and the fluid piped to the test area. Hydraulic control panels shall be permanently anchored and located as closely as possible to the stage.

Test cell design shall assure protection to surrounding factory areas, control rooms, and nontest personnel.

Test cell design shall be such that personnel access to the area is controlled and monitored.

The test cell area shall have a public address system for area or test announcements.

The test cell area shall have an intercommunication system to facilitate communication between the test personnel and the control room area.

The intercommunications system shall provide for acoustical monitoring of hazardous testing by incorporating microphone pickups to be strategically located in system to be tested.

Television monitoring shall be provided for control of the test area, including portable cameras for monitoring hazardous or critical tests.

The test cell area shall be a totally enclosed, well lighted, and temperature controlled area. Noise level should be held at a minimum.

Sufficient exits shall be provided for emergency evacuation of the cell.

Blow-out panels or vents shall be provided for relieving test volumes of air in case of test-vessel rupturing.

2.10 DATA AND REPORT REQUIREMENTS

2.10.1 General

Checkout data requirements are concerned with the identification of data originated in the process of assembled stage performance testing and the utilization of data for evaluation purposes.

A major advantage of an integrated assembled stage checkout system is that it will permit an effective utilization of the stage checkout data from the time the initial assembled stage tests are made at the factory until the time of mission completion.

An integrated data utilization plan is dependent not only upon an effective data retrieval plan, but also demands that the requirements associated with checkout data evaluation and analysis be anticipated in the initial preparation of the checkout procedures and programs.

The following paragraphs provide the criteria for assembled stage checkout data and report requirements, and discuss the initial requirements for an integrated data storage and retrieval plan.

The checkout data and report requirements contained in this document shall be used for those areas not specifically covered by MSFC Standard 263, Standard for Contractor Preparation of Data Submittal Documentation, and NASA Quality Publication NPC 200-2, Quality Program Provisions for Space System Contractors, April 1962 edition.

2.10.2 Data Requirements

Some of the inputs required from an integrated data storage and retrieval plan for the test and checkout operations are listed below.

2.10.2.1 Data Category

The following data categories are required:

- a. Receiving inspection data on procured flight items and GFE items.

- b. Preliminary test data on manufactured parts or assemblies.
- c. Calibration data on components, assemblies, subsystems, and systems.
- d. Measurement data on components, assemblies, subsystems, and systems.
- e. Running time data on components, assemblies, subsystems, and systems.
- f. Environmental test data.
- g. Assembled stage checkout data on stage subsystems and systems.
- h. Other data.

2.10.2.2 Data Source

The following data sources are required:

a. MSFC

- (1) Propulsion and Vehicle Engineering Division.
- (2) Manufacturing Engineering Division.
- (3) Astrionics Division.
- (4) Quality Assurance Division.
- (5) Test Division.
- (6) Launch Vehicle Operations Directorate.
- (7) Aeroballistics Division.
- (8) Computation Division.

b. Stage Contractors

- (1) S-I Chrysler - Michoud Operations.
- (2) S-IB Chrysler - Michoud Operations.
Chrysler - AMR.
- (3) S-IC Boeing - Michoud Operations.
Boeing - Mississippi Test Facility.
Boeing - AMR.
- (4) S-II NAA - Downey, California.
NAA - Santa Suzanna, California.
NAA - Mississippi Test Facility.
NAA - AMR.

- (5) S-IVB, S-IV Douglas Aircraft Corporation,
Santa Monica, California.
Douglas Aircraft Corporation,
Huntington Beach, California.
Douglas Aircraft Corporation,
Sacramento, California.
Douglas Aircraft Corporation, AMR.
- (6) RIFT Lockheed, Sunnyvale, California.
Lockheed, AMR.
- (7) Other Merritt Island Launch Area, LOC,
All stages.

2.10.2.3 Data Type

The following data types are required:

- a. Digital data.
- b. Analog data.
- c. Discrete data.
- d. Numerical data.
- e. Failure data.
- f. Experimental data.
- g. Laboratory data.
- h. Other data.

2.10.2.4 Data Coding

Each input listed under the data category above shall be symbolically coded and contain the following information:

- a. Date.
- b. Action to be taken.
- c. Stage under test.
- d. Test category (prestatic, static, post-static).
- e. System being tested.
- f. Type of component being tested.
- g. Medium or signal(s) handled by component.
- h. Medium or signal by which component is operated.
- i. Individual major component.
- j. Function to be performed on the component.

- k. The defect report number associated with a component which has malfunctioned.
- l. The defect and rework code for a component which has malfunctioned.

2.10.2.5 Data Formats

In accordance with the MSFC automation plan, the data format will be IBM 729, MOD II and MOD IV, binary coded decimal, on seven-channel magnetic tape, with a density of 200 or 556 bits per inch. In data generating areas where facilities are not available for recording on magnetic tape, a media of IBM punched paper tape and/or cards will be used.

Data printout from the data bank to the using agency will be displayed in tabulated report form.

Other formatting requirements will evolve as the studies and analyses of the above areas proceed.

2.10.2.6 Data Retrieval

The following preliminary guidelines shall govern the retrieval of data from the data bank.

- a. Each and every identifiable item shall be retrievable from the data bank.
- b. Data shall be retrievable to the least-significant entry.

2.10.2.7 Test Data

Test data shall be furnished in accordance with NASA Quality Publication NPC 200-2, Quality Provision for Space System Contractors. This publication requires that trouble, failure, and quality data on every part, component, equipment, and system shall be completely and accurately collected, processed, analyzed, and disseminated in a minimum of time to all pertinent areas within the contractor's organization, to the suppliers concerned, and to the cognizant NASA installation and its designated representative. The data applicable to assembled

stage checkout shall include, but is not limited to, that specified below and may be submitted in separate reports as generated.

Operational data reported shall include a complete description of operating or mission objectives, operating time, numerical results obtained, anticipated and actual functional and stress conditions, complete and detailed failure data including identification and description of part, component, or equipment that failed, the system or subsystem involved, conditions at time of failure, operating time to failure, mode of failure, date and geographical location of failure, how failure was observed, and recommendations.

2.10.3 Integrated Data Storage and Retrieval

To implement an integrated data storage and retrieval plan, a detailed study and analysis of data characteristics, categories, sources, formats, etc., must be undertaken. The results of this study should provide the guidelines for formatting and coding of the checkout and test data into a usable and manageable data storage and retrieval plan.

2.10.4 Report Requirements

The report requirements of the NASA Quality Publication NPC 200-2, Quality Program Provisions for Space System Contractors, and MSFC-STD-263, Standard for Contractor Preparation of Data Submittal Documentation, shall be followed in the preparation and scheduling of test reports. The following reports and information shall be submitted to the procuring activity as required.

2.10.4.1 Monthly Quality Status Report

Narrative comments, recommendations, tabulations of pertinent data, and summary of corrective action supplemented by graphs, photographs, or exhibits shall be compiled into a Monthly Quality Status Report which shall be submitted for information in accordance with paragraph 2.2 and Appendix B of NPC 200-2. When the contract requires mechanized or electronic processing of data, the data shall be transmitted as specified and the Monthly Quality Status Report shall provide a summary of results, corrective action, narrative information, and recommendations.

2.10.4.2 Narrative End-Item Report

The contractor shall prepare a narrative end-item report for each end item submitted under the contract schedule. The report shall cover the periods from subassembly installation through shipment, divided into major subheadings (e.g., for a vehicle stage, subassembly installations, pneumatic testing, hydraulic testing, optical alignment checks, subsystems test, end-item test, and inspection). The report shall identify the model and serial number of the end item and shall include, but is not limited to, information and comment on the following:

- a. Final configuration.
- b. An electrical procedures list.
- c. A list of replacements made during installation, test, and final checkout.
- d. A list of missing components at the time of shipment.
- e. A description of the troubles and malfunctions encountered in the stage and in each stage subsystem.
- f. The extent of retests that are required.
- g. A list of the tests which have not been completed satisfactorily.
- h. The total operating hours associated with each system and subsystem.

The final configuration of the stage prior to shipment from the factory location shall be documented by the stage contractor. Supporting this documentation shall be a complete set of drawings with the latest revisions, engineering order changes, red-lined system drawings used in final checkout, stage system and subsystem checkout data books, and electrical procedures list. The electrical procedures list shall contain the stage number, the component number, the component description, the component drawing number, the measurement number, the component operating range or nominal value, the component test procedure, the component serial number, the date the component was received, and the date the component was approved.

The list of replacements shall contain the component number, the serial number of the component installed, the component description, and the date of the installation of the replaced part.

The missing components list shall include, but is not limited to, the part number, the number required, and the component nomenclature.

The results of the over-all performance testing of the stage systems and subsystems shall be documented prior to shipment of the stage. This part of the report shall summarize the test results and shall describe the nature and causes of troubles and malfunctions, the corrective action that has been taken or is pending, the extent of retesting that is required, a list of tests which have not been completed satisfactorily, a list of engineering orders that have not been complied with, and a schedule showing the time and location during which the corrective action, retesting, or testing shall be performed. The above descriptions shall be furnished for the stage system tests and for each of the stage subsystems.

2.10.4.3 Stage Log Book

Log books shall be prepared for each stage prior to the completion of manufacturing checkout. Each log book shall contain:

- a. Index.
- b. A list of hardware which shall contain the identification and weight of all nondata sheet items (cables, structures, etc.).
- c. Inprocess test data.
- d. Acceptance test data for component, subsystem, system, and module level testing.
- e. Mass characteristics which specify the weight and location of the longitudinal center of gravity of the assembled stage.
- f. Significant event sheets which indicate significant items encountered during test and inspection activities.
- g. Test requirements which indicate temporary or permanent changes in test procedures or defined limits of acceptance of those specific values of out-of-specification limits and the authorization for this acceptance.
- h. Unit discrepancies including waiver information and how identified on accepted equipment. List all discrepancies

that occurred during processing and the disposition made of them.

- i. List of shortages.
- j. Dates of major processing milestones.
- k. Parts list by part number and serial number down to the smallest field-replaceable assembly.
- l. Engineering orders (a complete list of all engineering orders issued against the delivered item).
- m. Performance data and curves, including predicted thrust time-curves, pressure time curves, etc., if applicable.
- n. Calibration curves for all transducers.
- o. Defect summary report containing a tabulation of the number of defect reports written, the processing phase during which the defect occurred, and the category of the defect.
- p. Orifice summary containing the location, part number, size according to drawing callout, and actual size of every orifice.

2.10.4.4 Test Conductor's Log

A test conductor's log will be maintained by the test conductor from the time the stage is moved into the integrated checkout area. The log will contain the date, which will be followed by the significant entries for that day. Anything that affects the status of the stage or the checkout equipment and any problems that arise during checkout should be entered in the log. An example of the test conductor's log is shown in Figure 2-12.

2.10.4.5 Running-Time Log

A running-time log shall be maintained and a report furnished for all components that have been specified by reliability engineering as being critical from a time or cycling standpoint. This log shall include, as a minimum requirement, the component number, the component serial number, the date received, the date of initial operation, the tabulation of running time, and the component description.

DAILY LOG

TUESDAY
NOVEMBER 6, 1962

- 1) The vehicle was moved into Performance Test Area "A" and connected to the GSE. The S-IV dummy stage and payload were not available. The EBW firing units were not installed and the EBW ground equipment was not available. The ST-124P, flight control computer, flight control accelerometers, and horizon sensor also were not available.
- 2) The Power Distribution and Pneumatic Components Test was completed with satisfactory results. No console indication was received from engine 4 hydraulic fluid temperature indicator (4A10). The switch was found to be defective and was removed. Upon replacement of the switch, a proper console indication was received.

WEDNESDAY
NOVEMBER 7, 1962

- 3) The Cutoff Test was completed with satisfactory results. EBW equipment, normally verified during this test, was not available.
- 4) Preparations were completed for Overall Test No. 1.

THURSDAY
NOVEMBER 8, 1962

- 5) Overall Test No. 1 was run and evaluated. Results were satisfactory and the vehicle was released for Instrument Calibration.
- 6) Relay K7 in the tower test monitor (relay substitute for fuel tanks pressurizing) failed during Overall Test No. 1. The relay was removed and examined. One set of contacts failed to operate when the relay coil was energized. This was determined to be a mechanical failure in the relay and a defect report (#26336) was written. The relay was replaced and correct circuit operation obtained.

Figure 2-12. Sample Test Conductor's Log

2.11 SYSTEMS TEST

2.11.1 Introduction

This section establishes minimum requirements for the checkout of an assembled stage.

Assembled stage checkout refers to a series of performance tests on stage subsystems (in the stage network) and on the integrated stage. This checkout is generally accomplished at three specific times before the stage is transported to the launch site. These are as follows:

- a. Manufacturing Checkout: performed upon completion of the assembly process.
- b. Pre-Captive Test Firing (CTF) Checkout: performed prior to the CTF.
- c. Post-CTF Checkout: performed after the CTF.

The series of tests performed at these three times are similar. Test requirements may be altered somewhat due to the different objectives, but since checkout is, in general, the operation of the system, the alterations are not extensive.

This section describes the post-CTF that occurs subsequent to the CTF. The post-CTF is the most complete of the assembled stage test series. Manufacturing checkout does not include the steering over-all or plug drop tests. Pre-CTF checkout includes only those tests that the procuring activity requires to verify that the condition of the stage has not deteriorated as a result of its shipping environment, and provide assurance that the CTF will produce usable data with a minimum of predictable damage to the stage.

Prior to checkout the GSE undergoes verification testing. This testing is accomplished to insure that the GSE satisfies engineering requirements and will be compatible with the stage. It also provides a verification of the checkout programs. This testing is accomplished with a vehicle simulator designated the ground equipment test set (GETS).

In concert with the building block concept, the stage is subjected to the series of tests shown on Figure 2-13. These tests are described in detail in Section 2.11,

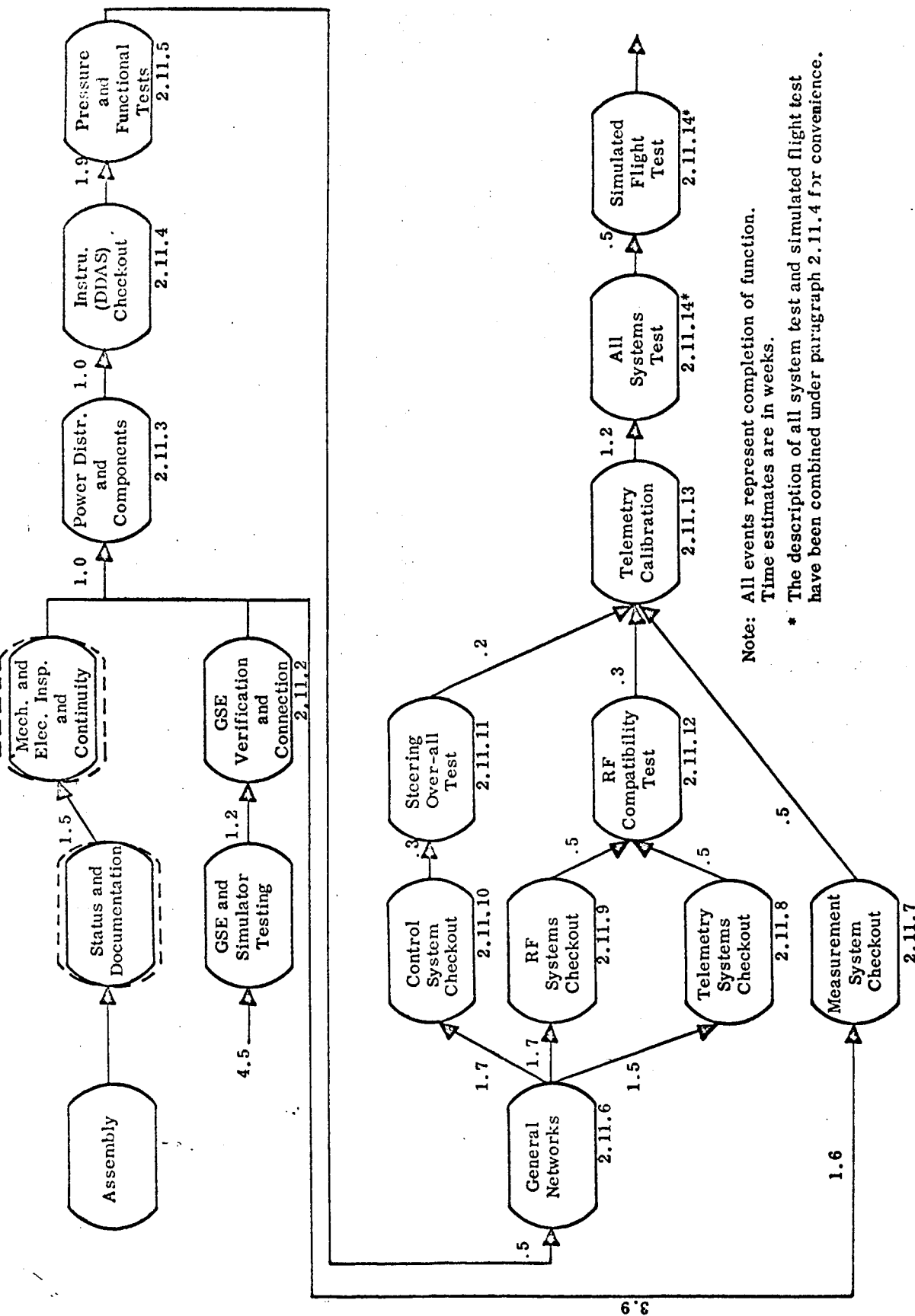


Figure 2-13. Manufacturing Checkout Flow for an Assembled Stage

and the tests consists, generally, of a checkout of the networks, subsystems, and systems which culminate in the simulated flight test (plugs in and/or out). During this test all systems are sequentially operated through their prelaunch and post-launch functions. Flight conditions (other than the special environment provided by actual engine operation and flight) are simulated. This test verifies that the stage will operate as an integrated system and in accordance with its design intent. Removal of any part or component that is a functional part of this test, which produces or reacts to stimuli or otherwise affects the operation of another part or component, will require that the simulated flight test be re-run. The decision to re-run systems tests or other levels of tests must be made in consideration of the facts surrounding the failure and the preciseness of the fault isolation techniques employed in localizing the failure.

Normally, repair activities will be limited to replacement of parts and/or components in the factory and at field test sites. Repair of parts or components will be made in laboratories which have been especially equipped for this type of activity.

The tests described in this section represent an application of the concepts related in the other parts of Section 2.0 of this document. Any deviation to the requirements of this section should be coordinated with the procuring activity.

The general objectives of assembled stage checkout are described in Section 2.4. Specific objectives for each test are listed in this section along with the detailed test requirements and a description of the test. It is emphasized, that the test conductors and test engineering personnel performing these tests should be thoroughly familiar with the stage and the stage checkout complex. This is necessary in order to realize the accomplishment of the intent of the objectives and the acquisition of the specified data.

The general requirements for assembled stage checkout are as follows:

- a. Stage checkout equipment shall be verified with vehicle simulation prior to its being hooked-up to the stage.
- b. A power distribution checkout shall be performed before general networks testing.
- c. Each subsystem (including electrical networks) shall be checked out separately in the vehicle networks before the integrated stage tests. (This is done to avoid the confusion caused by the interaction of systems.)

- d. Telemetry calibration should be performed after the completion of subsystems testing.
- e. The final test shall be a simulated flight test with the stage cycled through a simulated countdown and flight.
- f. Measured parameters shall be those presently instrumented in the flight system, whenever possible.
- g. The sequence of tests shall represent operational conditions as closely as possible.
- h. EMI tests shall be conducted on all systems and subsystems, as applicable, as a part of an active EMC program.
- i. Technical personnel (engineers and technicians), who have skill levels commensurate with their responsibilities, shall be provided.
- j. Sufficient numbers of personnel shall be provided to man the stations and perform the functions associated with this checkout.
- k. No component scheduled for flight shall be used to check out another component. When two flight articles are interconnected, the objective of the test should be to verify their compatibility.

The remainder of this section contains examples which illustrate the implementation of the above requirements. Specific requirements are given, where applicable.

2.11.2 Ground Support Equipment Verification

2.11.2.1 General Objectives

Prior to receiving the stage, all complex and ground support equipment is checked with the use of a ground equipment test set (GETS). This equipment is designed very flexibly by using patchboards with plug-in relay, diode, and switch modules and serves to obtain two objectives: the first is to check out the GSE to verify that it is designed properly, and that it is capable of checking out a stage; the second objective is to check out the programs that are to be used during stage checkout. This is accomplished by designing the GETS to present the same interface to the GSE as an actual stage.

For those stage responses that are presented on DDAS, a prerecorded tape is available that will be played into the DDAS ground station at the appropriate time.

2.11.2.2 General Requirements

To verify a new checkout complex, several tests will have to be performed; however, after the complex has been used to check out a stage, the only testing needed would be to verify any changes. There is no need in continually reverifying everything, and the GSE will be undergoing testing while developing the test programs for the succeeding stages.

In checking out a new complex four distinct tests will be performed, modification verification, power distribution and pneumatic components, general networks and malfunction, and over-all test.

2.11.2.3 General Functional Description

Prior to starting the tests to verify the GSE operational capability, its status is determined by checking all electrical and mechanical components to assure that they have been properly inspected and installed. All missing components and damaged wiring shall be listed and replacement or rework requested.

After the stage hardware status has been checked against documentation and the mechanical checks are completed, the GSE will undergo a complete checkout utilizing the GETS before it is mated to the stage. The initial test will be an end-to-end continuity measurement on all wiring and cabling to assure proper connections through the entire system. A rework is issued on any incorrect conditions and the inspection is then repeated. Megger checks are made on all cabling to assure adequate isolation between wiring. Measurement of all GSE power busses is made to verify conformance to calculated connected load. All busses are then checked to ascertain that they may be energized from the correct power supplies and in the correct sequence. The proper operation of all voltage, current, and sequence recorders associated with facilities is confirmed; moreover, verifying that the sequence recorders are

patched to record the prescribed events and yield the proper lamp illumination indications. Each circuit is then energized to ascertain that it receives power from the proper source. Subsequently, the functioning of each component is compared with its design intent and its compatibility with the complete system, including all elements of guidance and control, telemetry, and RF systems. A test is performed to verify that all sequences and programs function properly to simulate stage firing, and that all methods of initiating engine-cutoff produce the proper sequences and indications. Also, the proper functioning of all circuits associated with stage launch and malfunction engine-cutoff conditions is made. The compatibility of the control computer and GSE is ascertained by observing the responses to prescribed simulated positions. During the GSE verification testing, all test programs for stage testing are verified. Following the completion of GSE verification, the stage simulator is removed and the GSE is connected to the stage-for-stage checkout.

2.11.2.4 Modification Verification

2.11.2.4.1 Objectives

The objectives of the modification verification test are as follows:

- a. Verify the installation of all modifications required to update the checkout equipment, prior to delivery of the stage, has been accomplished.
- b. Verify that all modified equipment has been properly checked out.

2.11.2.4.2 Requirements

The modification verification test consists of the following:

- a. Ascertain that all of the emergency vent systems, pressure sensing devices, and pneumatic circuits are properly installed and are operational.
- b. Verify that all new circuits have been traced from their origin to their termination,

checking the installation of components and tube routing.

- c. Verify the continuity of each pneumatic circuit by using a low pressure flow test from source to vehicle connection point.
- d. A sample will be taken from each modified pneumatic circuit and analyzed for contamination.

2.11.2.4.3 Functional Description (Intentionally Omitted)

2.11.2.5 Power Distribution and Pneumatic Components

2.11.2.5.1 Objectives

The objectives of the power distribution and pneumatic component test are as follows:

- a. Verify that all busses may be energized from the correct power supplies and in the correct sequences.
- b. Check all circuitry associated with the control and monitoring of vehicle and ground components for proper supply buss, design intent, installation, continuity, and system compatibility using stage simulator such as GETS.
- c. Verify that all ground pneumatic components and lines are pressure tight, supplied with clean, dry gas, and will function at operational pressure upon command.

2.11.2.5.2 Requirements

Prior to starting formal testing the following prerequisites must be satisfied.

- a. Ascertain that all ground support equipment, facilities, stage simulation components,

subsystems, and systems have been installed and have been subjected to checkout on an individual basis.

- b. Ascertain that continuity checks have been performed on all wiring and cables and megger checks on all cables after the wiring and cabling was checked for accuracy by a prescribed wiring schematic.
- c. Verify that the proper pneumatic connections have been made.
- d. Insure that preliminary buss and power checks have been completed.
- e. Verify that all test, recording, and monitoring equipment to be used during test has been properly prepared.

After completion of the preceding checks, the following tests will be performed.

- a. Apply power to the complex to insure that it can be controlled in the proper sequence and the proper loads are presented.
- b. De-energize one power supply at a time, and monitor the bussing systems to verify the isolation of the primary busses.
- c. Cycle the GSE components, recording systems, and stage component control circuits to insure their proper operation and buss identity.
- d. Exercise the power circuitry to insure that the limit detecting components are functioning properly.
- e. Sample the gas used for vehicle pressurization and check for contamination and moisture content at the inlet to the checkout cart.

- f. Calibrate the pneumatic gage transducers.
- g. Check the emergency vent systems switch settings at the pressure switch and readjust as required.
- h. Analyze the recordings of the networks and power supply operations to insure all objectives have been met.

2.11.2.5.3 Functional Description (Intentionally Omitted)

2.11.2.6 General Network and Malfunction Test

2.11.2.6.1 Objectives

The objectives of the general network and malfunction test are listed as follows:

- a. Verify the operation of all malfunction cutoff circuits and the responses generated by the cutoff signals.
- b. Verify the ability to obtain preparations complete, check firing sequence interlocks, initiate power transfer tests, and initiate firing command allowing an automatic sequence of operation through liftoff. Verify design intent, compatibility, proper sequencing of events and programmed results.

2.11.2.6.2 Requirements

The following requirements should be satisfied before starting this test:

- a. The power distribution and components test using GETS has been completed.
- b. All test equipment to be used during tests has been properly prepared.

The following operations will be performed as the general network and malfunction test:

- a. Apply power to the complex and exercise the GSE to check all relay logic.
- b. Initiate firing command and introduce malfunctions to verify all methods of cutoff.
- c. Recycle the system to a safe status after each cutoff to prove that all systems can be controlled in the event of a malfunction.
- d. If necessary, perform special tests to check all timing functions.
- e. Analyze the recordings of the networks and power supply operations to insure all objectives have been met.

2.11.2.6.3 Functional Description (Intentionally Omitted)

2.11.2.7 Over-all Tests

2.11.2.7.1 Objectives

These tests are to verify the design intent and compatibility of all components of the GSE, as they must function as a system.

2.11.2.7.2 Requirements

The following requirements should be satisfied during this test:

- a. Apply power to the system and satisfy all requirements for preparations complete.
- b. Initiate firing command and allow the sequence to proceed in a normal fashion through power transfer, ignition, launch commit, and give liftoff by simulating plug ejection.
- c. Analyze all recordings taken during the test to verify proper operation.

2.11.2.7.3 Functional Description (Intentionally Omitted)

2.11.3 Power Distribution

2.11.3.1 Objective

Power distribution encompasses all power utilized on the stage to operate electrical networks and related electrical and electromechanical components. The purpose of this test is to assure compatibility of stage and support equipment, correct assembly, satisfactory power distribution, correct electrical and mechanical function, satisfactory design, and readiness for succeeding tests. This will include verification of the following:

- a. Proper mating of the GSE and stage.
- b. Proper distribution of power throughout the stage and ground system and the electrical operation of electromechanical components.
- c. The energization of all busses from proper power supplies and in the proper sequence.
- d. The control and monitoring circuitry associated with the stage having the proper supply buss, design intent, installation, continuity, and system compatibility.
- e. Proper impedance on all busses.
- f. Correct distribution of power so that no "shorts" or "sneak circuits" exist in the system.
- g. That the stage is prepared for succeeding tests such as pressure and functional tests.

2.11.3.2 Requirements

- a. Prior to proceeding with formal testing the following requirements must be satisfied:
 - (1) Electrical systems status determination has been completed where the exact status was determined by inventorying all electrical components and installed wiring to assure that it has been properly inspected and installed.

- (2) All missing components and damaged wiring have been listed and any replacement or rework has been requested.
 - (3) Electrical continuity tests have been completed where all wiring was checked for continuity and megger checks were made on all cables.
 - (4) Verify GSE-stage connections according to interconnecting diagram.
 - (5) Prepare test equipment to be used during test.
 - (6) Disconnect all RF and G and C equipment.
 - (7) Make all required mechanical connections between GSE and stage.
 - (8) Ascertain that all switches are in the off or normal position.
- b. When all prerequisites have been satisfied tests will be conducted to:
- (1) Ascertain that all power connections have been made and that the resistance of all supply busses are correct.
 - (2) Verify that the power is properly applied in the proper sequence to all circuits, electrical networks, electromechanical and electrical components, and that the load on all busses is correct.
 - (3) Ascertain that all electrical controls operate properly to control pneumatic supplies, pressurization and venting valves, propellant fill and drain valves, pre-valves, air bearing valves, and all other system valves in preparation for subsequent tests.

2.11.3.3 Functional Description

After a continuity check has been completed on the stage electrical system wiring and cabling, plus insulation resistance checks in all cables, the first test will be to ascertain that power can be successfully applied to the stage. The application of power to the stage will confirm the electrical operation of the valves and pressure switches associated with the propulsion system; namely, vent valves, fill and drain valves, replenish valves, prevalues, LOX manifold valves, propellant utilization

valves, purge valves, overfill pressure switches, and tank pressure. Also, verify that power is applied in the proper sequence to all circuits and components, and verify that the load on all busses and ac heater load distribution is correct. In addition, the independence of busses should be confirmed. The proper operation of the cooling system including calibration shall be accomplished. The completion of this test should adequately prepare the electrical system of the checkout complex for the general networks test.

2.11.4 Airborne DDAS Calibration

2.11.4.1 Objectives

This calibration is to assure the airborne DDAS is accurately calibrated for its use as a checkout tool prior to the commencement of testing.

2.11.4.2 Requirements

Prerequisites for this calibration are a validly calibrated DDAS ground station, completion of the power distribution test, and completion of component checkout in a bench test setup.

Parameters to be measured are the analog outputs of the DDAS ground station.

2.11.4.3 Functional Description

All input cables to the telemetry packages will be disconnected and re-routed, via test cables, to a switching unit located outside the stage. This switching unit will be capable of routing the signals on these cables to the recording facility or to the airborne DDAS. All channels will be provided with at least a 3PT calibration. The output of the DDAS ground station will be compared to the hardware output.

2.11.5 Pressure and Functional

2.11.5.1 General Objectives

The objective of performing pressure and functional tests on the mechanical systems of the stage is to insure the integrity and functional capability of the mechanical systems in the stage. It is also necessary to insure that the stage has been manufactured correctly, and that the stage has not been altered or damaged by any testing or transportation. The checkout shall not be a matter of merely making visual or functional type inspections in conformance with the design specifications, but rather it is an operational test to determine the ability of the system to meet its mission requirements.

2.11.5.2 General Requirements

Methods outlined in this paragraph shall be adhered to:

- a. All connections that are disconnected in order to perform a test must be retested for leakage.
- b. Leak test solution shall not be used on braiding of flexible lines, bellows, pneumatic bleed ports, or flared surfaces of A.N. fittings and tubings.
- c. All leak detection solution shall be completely removed from all fittings, lines, components, and assemblies, with an approved solvent, after testing. Care shall be exercised to prevent foreign matter from entering vents, bleed, or pilot openings.
- d. All protective covers removed from the stage and test equipment shall be immediately replaced upon completion of test.
- e. At no time shall any line connections or fittings, flanges or fixtures be disconnected while a system is pressurized.
- f. All systems being tested shall be pressurized slowly to, but not to exceed, the specified pressures of the system.
- g. If any audible leakage is detected within the specified pressure range, it shall be marked and recorded for correction.

- h. All test lines, connections, fittings, and fixtures shall be tested and free of external leakage prior to beginning a pressure "drop-off" test.
- i. All pressure "drop-off" tests shall be timed and recorded on permanent records.
- j. Where it is not convenient to measure leakage by using downstream flowmeters or upstream flowmeters, the system shall be pressurized to a known volume and pressure, a decay test shall then be performed.
- k. All high-pressure tests shall be conducted utilizing incremental pressure steps. Five-minute intervals are recommended between pressure steps.
- l. Audible leak detectors shall be utilized during high-pressure tests to inform the test conductor of system audible leaks.
- m. Structural system pressurization tests shall be conducted at proof pressure, with the test cell evacuated of all personnel. Then systems will be checked at safe pressure with personnel in test cell to check for leaks. Systems shall then be vented and a trace gas leak check shall be conducted.
- n. Any faulty pressurized system must be depressurized before repairs are attempted.
- o. Tracer gas utilized for leak detection shall be handled in such a manner as to avoid contaminating areas where future leak tests will be conducted. Systems tested with trace gas shall not be vented into these areas.
- p. In the event any system is "opened" after a leakage test has been performed, the system shall be retested for leakage.
- q. Using leak detection solution or tracer gas, check all fittings, tubing, connections, and flanges relevant to the stage systems.
- r. Flowmeter or pressure decay tests shall be utilized to check all valve seats, seals, etc.

- s. Care shall be exercised to insure that the pressure range of pressure transducers in any system shall not be exceeded during system pressurization tests.
- t. All pressure gages and pressure transducers must be calibrated within 30 days before use in testing a stage.

2.11.5.3 General Functional Description

During this test, electrical and pneumatic power is applied to the stage mechanical systems and subsystems. Pneumatic power in the form of gas pressure is used to determine the integrity of pneumatic and propellant systems and to verify the proper functioning of various components. Electrical power is used to control various components in this system. Records of all system actuation timing, pressure levels, etc., are obtained and recordings of all communication conducted during the test are collected.

2.11.5.4 AC Heaters

2.11.5.4.1 Objectives

Verify heater operation by measuring the heater current and voltage, and checking thermostat actuation by measuring temperature range through which thermostat cycles.

2.11.5.4.2 Requirements

- a. Connect necessary wiring and instrumentation to perform test.
- b. Attach transducers as near to the thermostat as possible without direct contact being established with the heater elements.
- c. Verify that proper voltage is applied to insure validity of current readings received.
- d. All heater units must be cycled three times and the three results must be compared to insure normal operations.

- e. Compare, display, and print out amperage drawn by each heater and temperature limits of the controlling thermostat for three cycles of each component.

2.11.5.4.3 Functional Description

During this test the heaters utilized on cryogenic components are tested to insure they operate within their specified temperature range, drawing the correct operating current at the proper voltage. This is accomplished by supplying electrical power to the heaters and measuring the skin temperatures of the components as well as measuring the current drawn by the heater elements.

2.11.5.5 Pressure Switches Test

2.11.5.5.1 Objectives

The objectives of this test are to verify pressure switch operation, to leak test at system pressures, check for internal and external leakage, verify actuation and deactuating pressure settings, and make and break repeatability of the switches.

2.11.5.5.2 Requirements

- a. Connect necessary pressure line, wiring, and instrumentation to perform test.
- b. All pressurization cycles are to be performed three times in order to insure consistent results.
- c. All systems shall be pressurized at a reasonable rate to maintain adequate control. (High-pressure systems should be limited to a maximum pressurization rate of one percent of maximum system pressure per minute near upper limits.)

- d. All pressurization system connections shall be leak checked at an intermediate level of operation.
- e. Go to system pressure slowly and vent to zero slowly for each cycle.
- f. All systems shall be checked for leaks on first pressurization cycle. Actuation and deactuation pressures shall be determined on the first and subsequent cycles. All switches shall be cycled three times by going to system pressure and then venting to zero for each cycle.

2.11.5.5.3 Functional Description

All pressure switches are actuated by pressurizing systems to operating pressure. The actuations and deactuations are observed and recorded during increasing pressure and decreasing pressure, and they are checked to determine if they are within specified tolerances. Internal and external leak checks of all switches are performed using leak detection solution at operating pressures. All connections are also leak checked.

2.11.5.6 Control Pressure System

2.11.5.6.1 Objectives

The objectives of this test are to check system integrity, external and internal leakage of the system and components, minimum pressure required for component operation, and relief settings of high pressure regulator and system relief valves. In addition, check response timing and repeatability of component operation, proof test system and components at normal system operating pressure, and check and assure that the GN₂ control system purges are within specification.

2.11.5.6.2 Requirements

- a. Audible leak check of the high-pressure system shall be performed at a reduced pressure level.
- b. High-pressure systems shall be pressurized using suitable increments (i.e., 500 psi steps). The maximum pressure level shall be maintained for five minutes.
- c. All high-pressure connections, components, bottle fill, and vent valves seat shall be leak checked.
- d. All system valves shall be checked for reverse leakage and allowable limits determined.
- e. All system valves shall be checked to ascertain that they will actuate to full-open position.
- f. All relief valves shall be checked to determine cracking and seating pressures are within specification.
- g. All prevalues, relief valves, replenishing valves, fill and drain valves, and vent valves shall be time checked.
- h. All valves shall be cycled three times and the three results compared to insure normal system operations.

2.11.5.6.3 Functional Description

The actuation, internal leak check, and external leak check of all control valves are conducted by pressuring system to proof pressure. All high-pressure components and connections are leak checked using suitable leak detection procedures. Reverse leakage of all components is also checked. External leak checks of all system lines are conducted while pressurized at safe levels and with no leakage allowable.

2.11.5.7 Gas Generator Oxidizer and Fuel Control Valve Assemblies

2.11.5.7.1 Objectives

The objectives of this test are to check external leakage of components and connections, internal leakage of poppet seats, pressure required to open poppets, and the repeatability of operation of the system components.

2.11.5.7.2 Requirements

- a. The cracking pressure of all system valves shall be determined.
- b. All system connections shall be checked using suitable leak detection solution.
- c. Internal leakage of all valves shall be checked.
- d. The main oxidizer and fuel valves shall be cycled three times, and the results obtained must be consistent.
- e. The repeatability of all system components must be ascertained.

2.11.5.7.3 Functional Description

The external leakage of all connections and components are checked with the system pressurized, using audible, leak detection solution, and pressure differential means. All components are operated to determine proper actuation and deactuation pressure levels and timing.

2.11.5.8 Gas Generator, Gas Turbine, Turbine Exhaust, and Turbopump Gearcase Test

2.11.5.8.1 Objective

The objectives of this test are to check for external leakage, turbine seal leakage, turbopump torque, audible noise during turbopump torque test, and cracking pressure of lube oil drain check valve and its repeatability. A 10 psi test of gearcases is conducted to assure no adverse conditions exist.

2.11.5.8.2 Requirements

- a. Remove dust caps, pressure caps, and/or pressure plugs from the systems to be checked. (Replacement of all caps and plugs shall be accomplished as soon as tests have been completed.)
- b. All connections and fittings shall be checked for leaks using a suitable leak detection solution. No external leakage shall be allowed.
- c. Turbine seal leakage shall be checked with a suitable flowmeter.
- d. All bellows, flanges, and welds in these systems shall be leak checked with a suitable tracer gas. No leakage shall be allowed.
- e. Turbopump gearcase fittings, connections, measurements, flanges, and tubing shall be checked with a suitable tracer gas. No external leakage shall be allowed.
- f. Turbopump gearcase pressurization check valves shall be checked for reverse leakage.
- g. Any repairs made in these systems will require retest of the repaired system.

2.11.5.8.3 Functional Description

The propellant transfer system is pressurized and tested for component reverse leakage. All components are leak checked using tracer gas and leak detection solution. Component operations are checked to verify actuation and deactuation timing. All connections are leak checked with the system pressurized using leak detection solution and tracer gas methods.

2.11.5.9 Engine Control System Tests

2.11.5.9.1 Objectives

The objectives of this test are to check for external and internal leaks, minimum pressure required for main oxidizer valve and main fuel valve operation, for "no actuation" and "actuation" of ignitor monitor valve, position potentiometer of main oxidizer valve and main fuel valve for closed position, open position and total valve position, functional operation of sequence valve, and system integrity. Also a check of response, timing, and repeatability of main oxidizer valve, main fuel valve, ignitor monitor valve, and proof test system for components at normal operating pressures of the system is conducted.

2.11.5.9.2 Requirements

- a. All connections, fittings, and housings must be leak checked with a suitable leak detection solution. No external leakage allowed.
- b. Internal leak check around O-rings and other seals shall be conducted utilizing flowmeters.
- c. All valves shall be checked for cracking and seating pressures and must comply with specifications.
- d. All system components shall be checked to assure they are operative and capable of obtaining full-open position.
- e. All test fixtures installed in a system must be red-tagged with a tag of sufficient size to insure detection.
- f. All systems that are disconnected to install test fixtures must be rechecked for leakage.
- g. Oxidizer and fuel valves shall be checked for smooth operation (no binding or sticking allowed).
- h. All valves shall be leak checked for reverse leakage.

2.11.5.9.3 Functional Description

The engine control system is functionally checked to insure all valves can be actuated to their full extent without binding or sticking. All connections and components are externally and internally leak checked by pressurization of the system to insure system integrity.

2.11.5.10 Oxidizer Pressurization System

2.11.5.10.1 Objectives

The objectives of this test are to check for binding, bending, squirming of oxidizer lines and expansion joints, for external leakage, for internal leakages of check valves, and for system integrity. The system shall be pressurized to proof pressure.

2.11.5.10.2 Requirements

System lines shall be pressurized to proof pressure slowly and a pressure drop-off test performed for five minutes at proof pressure.

2.11.5.10.3 Functional Description

The oxidizer pressurization system is checked at proof pressure for leakage and functional operation. The system is pressurized and checked for pressure decay and reverse leakage of valve seats. Leak detection solution and tracer gas are utilized for external leakage checks.

2.11.5.11 Engine Purge System

2.11.5.11.1 Objectives

The objectives of this test are to check for external leakage, system integrity, and proof test at normal system operating pressures.

2.11.5.11.2 Requirements

- a. System lines and storage equipment shall be proof checked at operating pressure and a drop-off test conducted.
- b. A leak check of all lines, fittings, and connections shall be conducted under pressure, utilizing a suitable leak detection solution. No external leakage is allowable.
- c. Internal leakage of the system shall be tested with a flowmeter.

2.11.5.11.3 Functional Description

All engine systems that are connected to the purge system are functionally and leak checked at proof pressure. External and internal leakages are also checked by pressurizing the systems and insuring pressure integrity.

2.11.5.12 Air Bearing System

2.11.5.12.1 Objectives

The objectives of this test are to check for external leakage, and proof test at system operating pressures. The air bearing regulator is checked for pressure regulation, flow regulation, bypass and flow, and buildup and stability.

2.11.5.12.2 Requirements

- a. System shall be proof tested for leakage at operating pressure.
- b. High-pressure systems shall be pressurized using pressure increments.
- c. All connections and fittings shall be leak checked using suitable leak detection solution.
- d. Precooling valves shall be leak checked. No reverse leakage is allowable.

- e. Instrumentation canister shall be pressurized using pressure increments. Holding time intervals will be established between pressure steps.
- f. Maximum pressurization rate of canisters will be one psi per minute.
- g. Audible leak detection methods will be employed to perform this test.
- h. All pressure caps will be installed as soon as test has been completed.

2.11.5.12.3 Functional Description

The airbearing system of the inertial guidance system is checked for high-pressure leaks by pressurizing to proof pressure. All connections are leak checked, and the system canister is leak checked with the system pressurized.

2.11.5.13 High Pressure Pressurization System

2.11.5.13.1 Objectives

The objectives of this test are to check for external leakage, check regulators for pressure and flow regulation, check slosh regulators for flow regulation, and check system integrity. A pressure drop-off test shall be performed, and the system shall be proof tested at operating pressure.

2.11.5.13.2 Requirements

- a. System shall be pressurized using increments (i.e., 500 psi).
- b. A leak check of all fittings shall be conducted at increments during pressurization using audible leak detection methods. A suitable lapse period shall be allowed between increments.

- c. Test area will be cleared of all personnel during these high-pressure tests.
- d. All regulator, check valves, and bypass valves connections and fittings shall be leak checked using a suitable leak detection solution. No external leakage is allowable.
- e. All systems shall be maintained at operating pressure for five minutes to perform a pressure drop-off test.
- f. All valve seats shall be checked for internal and external leakage.

2.11.5.13.3 Functional Description

The high-pressure pressurization system components are leak checked at appropriate pressure levels, and the entire system integrity is verified. Flow rates of critical components are verified using flowmeters.

2.11.5.14 Oxidizer Tank and Combustion Chamber Test

2.11.5.14.1 Objectives

The objectives of this test are to check for external leakage, internal leakage of vents and valves, system integrity, binding in all expansion joints and bellows on interconnects and feed lines, bending and squirming, and functional operation of all components. The system is proof tested at operating pressure.

2.11.5.14.2 Requirements

- a. Test area shall be cleared of all personnel before oxidizer tanks are pressurized.
- b. Leak checks shall be conducted using audible leak procedures, tracer gas, and leak detection solution to check all fittings, connections, and flanges.

- c. Internal leakage checks of all valve seats shall be conducted utilizing flowmeters.
- d. If any unusual noises are detected during these tests, pressurization must be stopped, system depressurized, and discrepancies corrected before any further pressurizations are attempted.
- e. Oxidizer tank shall be pressurized in increments to proof pressure. A suitable time interval shall be allowed between increments. System shall be maintained at proof pressure for five minutes. Pressure shall be reduced to safe level before personnel entry is allowed.
- f. Oxidizer tank shall be checked for audible leaks at safe pressure level.
- g. Oxidizer turbopump shall be checked for oxidizer seal leakage and torque required to rotate each pump.
- h. All combustion chamber purge lines shall be leak checked using suitable leak detection solution.
- i. All combustion chamber purge lines shall be leak checked.
- j. A functional check of all component operation shall be conducted.

2.11.5.14.3 Functional Description

The oxidizer tank and combustion chamber tests are conducted to verify system integrity by pressurizing the systems and checking for external and internal leakage. Operating components are functionally tested to insure system compatibility by operating each component.

- i. Tracer gas leak checks of fuel tanks shall be conducted after audible leak checks. A suitable tracer gas detector shall be utilized to check for leakage.
- j. Fuel turbopump seal leakage and torque shall be checked.
- k. A functional check of all system components shall be conducted.

2.11.5.15.3 Functional Description

The high-pressure spheres and fuel tanks are pressurized to check system integrity. External and internal leakage is checked by use of audible, tracer gas, leak detection solution, pressure drop-off test, and flowmeters. All systems components are functionally checked to insure operation.

2.11.5.16 Hydraulic System

2.11.5.16.1 Objectives

The objectives of this test are to check hydraulic system for proper response, maximum deflection, and system integrity. Each engine is gimballed to verify structural clearance.

2.11.5.16.2 Requirements

- a. All personnel must be cleared from vehicle tail area before hydraulic systems are actuated.
- b. Visual checks shall be conducted to assure clearance with respect to surrounding stage equipment.
- c. Visual checks for twisting, buckling, or stretching of flexible hoses or wiring.
- d. Visual checks for evidence of leakage.
- e. Check of smooth operations of system.

2.11.5.15 High Pressure Spheres and Fuel Tanks

2.11.5.15.1 Objectives

The objectives of this test are to check for external leakage, internal leakage of components, functional operation of components, binding in all expansion joints and bellows, bending and squirming, and system integrity. The system is proof tested at operating pressure.

2.11.5.15.2 Requirements

- a. All personnel must be cleared from test area prior to pressurization of the fuel tanks and high-pressure spheres to proof pressure levels.
- b. Fuel tanks shall be pressurized in increments allowing suitable time lapse between increments.
- c. High-pressure system shall be pressurized in increments allowing suitable time intervals between increments.
- d. Proof pressure test shall be conducted on the high-pressure systems and the pressure drop-off observed.
- e. External leak checks using audible leak detection procedures and tracer gas shall be conducted at safe pressure levels.
- f. All fittings and connections shall be leak checked utilizing suitable leak detection solution.
- g. Internal leak checks of all valves shall be conducted utilizing flowmeters.
- h. Audible leak checks shall be made of the fuel tanks. No audible external leakage is allowable.

- f. A check shall be conducted to assure ability to fully extend and retract both the pitch and yaw actuators simultaneously (corner clearance check).
- g. All actuator locks must be installed at completion of tests.

2.11.5.16.3 Functional Description

The hydraulic system is functionally checked by actuating each system and observing engine movement. Structure clearance is observed visually.

2.11.5.17 Instrument Canister and Cooling System

2.11.5.17.1 Objectives

The objectives of this test are to check structural integrity for external leakage and components for internal leakage and operation of cooling system components. A proof test is conducted at suitable pressure, and a pressure drop-off test is conducted.

2.11.5.17.2 Requirements

- a. Audible and visual leak checks shall be conducted over a suitable pressure range.
- b. A minimum number of personnel shall be allowed in test cell to detect leaks while system is pressurized.
- c. Instrument canisters shall be pressurized slowly utilizing increments of pressure. Sufficient holding times shall be allowed between pressure steps.
- d. After maximum pressure level has been obtained a suitable drop-off test shall be conducted.

- e. All system connections and fittings shall be leak checked with a suitable leak detection solution.
- f. All system valves shall be leak checked for reverse flow.
- g. All pressure caps, quick disconnects, plugs, etc., must be installed in system as soon as tests are completed.

2.11.5.17.3 Functional Description

The instrument canister and cooling system is leak checked by pressurizing system and using tracer gas. Audible, visual, tracer gas detectors, and pressure drop-off methods are utilized.

2.11.6 General Network and Malfunction Tests

2.11.6.1 Objective

The stage electrical system provides for the integration of all subsystems into a functional unit; therefore, it will be necessary to verify the basic network system prior to subsystem component testing.

The test objective will be to verify assembly, design, function, and compatibility of networks and cutoff circuitry. This will include power transfer tests, preparations complete, firing command, simulated ignition, panel cutoff, malfunction sequences, recycling to prelaunch conditions, normal propulsion sequence to liftoff (umbilical not retracted during prestatic, retracted during post-static), flight sequencer, depletion circuits, EBW systems, cutoff and separation circuits. During post-static testing verify the operation of camera systems and command receiver destruct. In addition, verify status and operation of other components necessary to qualify the vehicle for succeeding tests.

2.11.6.2 Requirements

Prior to the initiation of formal testing the following prerequisites must be satisfied:

- a. The power distribution and components test has been completed.
- b. The stage and GSE cabling is proper according to the preparation steps in the test procedure.
- c. All mechanical connections have been made.
- d. All switches have been verified to be either in the off or normal position.
- e. All required components prescribed by the test procedure have been disconnected.
- f. All required test equipment has been properly prepared.

The following test operations will be performed to ascertain the applicable equipments compliance with specified parameters:

- a. Exercise all circuits required to obtain firing command.
- b. Initiate power transfer from ground power to stage power and return.
- c. Exercise the stage flight sequencer to ascertain its proper operation.
- d. Exercise all methods of cutoff. This may entail giving firing command and introducing malfunctions to ascertain if the malfunctions can be detected and the proper action taken.
- e. After each cutoff, recycle the system to prelaunch condition to prove that after each, the system can be recycled to a safe condition.
- f. Exercise all elements of the CDR system, retrorockets, ullage rockets, and separation systems.
- g. Conduct special tests, if necessary, to verify each redundant circuit.

2.11.6.3 Functional Description

The initial part of this test will consist of verifying the network circuitry associated with vehicle engine cutoff in the following areas: command-destruct system with command receivers, flight sequencer, propellant depletion circuits, and low thrust cutoff circuits. The EBW in the retrorocket and destruct systems are verified.

The sequence of switching necessary for preparations complete is checked, followed by a check of various premature cutoff sequences by introducing malfunctions into the automatic sequence after firing command. A normal firing sequence is accomplished with umbilical retraction occurring automatically at the appropriate time. The umbilical retraction is simulated during the prestatic tests. The one-shot safety relays are test fired. Cutoff is given after liftoff by the ground command transmitter via the stage command receivers. Since no guidance and control equipment is connected during this test position, indicators are simulated.

The tests will be performed by operational use of launch GSE control panels, networks test panels, and equipment contained in the instrumentation ground stations. Proper operation of the networks will be determined by observation of voltage and current recorders, lamp indicators, and by analysis of event recorder records.

2.11.7 Measuring System

2.11.7.1 Test Objectives

- a. To verify the calibration of all transducers located on the stage.
- b. To verify the calibration of the signal conditioners associated with the transducers.
- c. To assure system conformance to proper channel assignments as determined by applicable documentation.

2.11.7.2 Test Requirements

a. Prerequisites

- (1) Calibration of DDAS ground station and recording equipment.
- (2) Valid, timely calibration curve on each transducer.
- (3) Visual inspection of installation.

b. Parameters

The parameters to be checked are:

- (1) High-level dc voltages, e.g. receiver AGC's.
- (2) Low-level dc voltages, e.g. strain gages.

- (3) High-level ac voltage, e.g. inverter output frequency.
- (4) Low-level ac voltages, e.g. vibration transducers.
- (5) Event indication, e.g. valve closures. Other parameters are linearity, hysteresis, rise time, duration, frequency (audio region), etc.

2.11.7.3 Functional Description

Each signal conditioner is provided with a calibrated input. The output of the signal conditioner is returned to ground via the DDAS, where it is compared in the computer to the stored calibrated value. No data is printed out at the data system test station.

To aid the calibration of the signal conditioners, technicians on the stage are provided with a remote indicator unit which is driven by the computer. This unit displays the "out of cal" condition and indicates to the technician which direction to tune. When the signal conditioner is calibrated, the technician presses a button which informs the computer he has finished and is going on to the next signal conditioner. This test consists of the physical actuation of all transducers after they are installed in the stage. This provides a continuity check from source to telemetry channel, as well as a check on the operation and location of the transducer and its associated circuitry. Next, whenever possible, a calibrated stimulus should be applied to the transducer. In some cases this will merely be a high and low calibration check of the signal conditioner associated with the transducer and with the ambient output of the transducer providing a third point.

If it is not possible to physically stimulate the transducer, it should be simulated. Simulation should be as close to the transducer as possible. An end-to-end check of every channel must be made.

Many of the measurement checks can be made in conjunction with the checkout of other systems. Examples of these are receiver AGC's during RF checkout and valve closures during pressure and functional checks.

2.11.8 Telemetry Systems

2.11.8.1 Test Objectives

Determine that the telemetry system can operate in compliance to applicable specification while installed in and controlled via stage networks.

2.11.8.2 Test Requirements

a. Prerequisites

- (1) Completion of functional checkout (including timing and calibration) of all TLM system components in a bench test setup.
- (2) Tuning of TLM antenna systems.
- (3) Visual inspection of stage installation.

b. Parameters

- (1) Transmitter powerout and reflected power.
- (2) RF amplifier power output and reflected power.
- (3) All voltages on main and RF power amplifier chassis.
- (4) Calibration programming.
- (5) Calibration step amplitude.
- (6) Commutator speed.
- (7) Transmitter frequency and deviation.
- (8) Spurious signals of each transmitter.
- (9) Spurious signals of multicoupled transmitters.
- (10) Subcarrier oscillator frequency, deviation, stability, linearity and pre-emphasis.
- (11) Multicoupler efficiency.
- (12) Auxiliary equipment as required, e.g. flow rate multiplexer.

2.11.8.3 Functional Description

All parameters, as a minimum, listed above will be measured (either manually or automatically while the TLM system is operating in the stage network in as near a flight configuration as possible. These measurements will be compared with measurements obtained previously in the functional bench check to determine trends and for compliance with applicable specifications. Calibration of subcarrier oscillators will be checked and adjusted as necessary.

2.11.9 RF Systems

2.11.9.1 Test Objectives

To determine if the RF systems can be operated in accordance with applicable specification when installed in and controlled via stage networks.

2.11.9.2 Test Requirements

Prerequisites for this test are the successful completion of components testing, antenna systems calibration, and a visual inspection of the stage installation.

Parameters measured during this test will vary according to the item under test, but they will include receiver bandwidths and sensitivities, frequency measurements and drift, pulse repetition frequencies, pulse jitter, rise time, length, etc.

2.11.9.3 Functional Description

In general, this test will be an abbreviated repeat of the component bench check. For instance, if a receiver AGC calibration was checked on the bench with 15 points, it may be checked on the vehicle with only five points. The operation of the systems may be open or closed loop, with preference given to open loop operation, since this more nearly approximates the flight configuration.

2.11.10 Thrust Vector Control System

2.11.10.1 Flight Control Switching

2.11.10.1.1 Test Objectives

The objectives of these tests shall be to verify the operation of the stage flight-control switch.

2.11.10.1.2 Test Requirements

Prior to assembled stage testing of the flight control switch, the following prerequisites shall be met.

- a. Assembly shall be complete.
- b. Visual checks of the component and its mounting shall have been made.
- c. Component tests shall have been made to verify performance and to accumulate data.

Stage power is required for these tests and shall be furnished via the stage networks.

These tests shall be run via a computer controlled Test Station.

2.11.10.1.3 Functional Description

With the stage power on, a reset command shall be applied to the flight control switch. The connections between the stage interface set and the engine gimbaling system servo valves and the engine position measurement potentiometers shall be tested for an open circuit condition.

Next, an enable command shall be applied to the flight control switch. This operation completes the connections between the stage interface connectors and the engine gimbaling system servo valves and the engine position measurement potentiometers. Continuity measurements shall be made to verify the circuits which are switched by the control switch. Upon completion of these tests the control switch shall be returned to the reset condition.

2.11.10.2 Engine Gimbaling System

2.11.10.2.1 Test Objectives

The objectives of the engine gimbaling system checkout during assembled stage tests are as follows:

- a. The linearity of the engine gimbaling system position (measurement) potentiometer shall be verified for each of the individual engines. Position voltages or measurements shall be recorded and compared with specified values.
- b. The response of each engine gimbaling system to selected stimuli (i.e., ramp functions) shall be determined and recorded for comparison with previously derived response parameters.

2.11.10.2.2 Test Requirements

Prior to assembled stage testing of the engine gimbaling system, the following prerequisites shall be met:

- a. Assembly shall be complete.
- b. Checks of each engine assembly for mounting, alignment, and possible interference with stage structure or an adjacent engine shall have been made.
- c. Both static and dynamic tests of each engine gimbaling assembly shall have been made to verify performance and to accumulate operational data on each of the engine actuations systems.

The operation of the servo valve amplifier shall be verified prior to connection to the stage engine actuation systems.

Stage power is required for these tests and is furnished via stage networks to the electrically operated auxiliary motor and pump and other control components. The stage instrumentation system is active during a portion of these tests so that the calibration of the engine gimbaling system potentiometer may proceed in conjunction with the linearity tests. When the auxiliary hydraulic pumps are turned on, measurement personnel shall be requested to monitor hydraulic oil

temperature and to notify the test conductor when this temperature exceeds a specified level. At this temperature the pump shall be turned off and the oil allowed to cool. The proper, safe shutdown procedure for the engine gimbaling system shall be established so that power may be removed from the engine gimbaling system in case of serious malfunction. Each of these tests shall be controlled and monitored via the appropriate test station.

Control system personnel shall always be present at the rear or lower end of the stage to verify that engines are clear to be gimbaled.

These tests may be automated or partially automated through an appropriate test station. A computer program for each of these tests shall be written and verified prior to use in the assembled stage tests of the engine gimbaling system.

2.11.10.2.3 Functional Description

The servo valve amplifier provides current to each of the individual engine actuator pitch and yaw servo valves to drive the engine to a specified position in pitch or yaw direction. This procedure shall be repeated for plus and minus 2 degree steps from the zero degree position out to the maximum allowable excursion specified for each engine. This test procedure shall be repeated for each of the movable engines on the stage. Comparison of the measured position data with specified values shall be a computer operation. The test progress shall be monitored at the appropriate test station.

Stimuli which have been generated, controlled, and monitored within an appropriate test station shall be applied to the input of the servo valve amplifier to measure the engine gimbaling system response. The servo valve amplifier input and output signal as well as the position measurement for each engine

shall be monitored and recorded during these tests. The response of each of the movable engines to a sinusoidal and ramp type functions shall be measured, where applicable, and compared with existing response data.

2.11.10.3 Rate Gyro Assembly Tests

2.11.10.3.1 Test Objectives

The objectives of the assembled stage tests of the rate gyro assembly are to verify proper functioning of the rate gyros and their associated electrical support equipment.

2.11.10.3.2 Test Requirements

The prerequisites to the assembled stage tests of the rate gyro assembly shall be as follows:

- a. Assembly on the stage shall be completed.
- b. Checks on component mounting and alignment shall have been made.
- c. Testing of the rate gyros at the component level and as part of an assembly shall have been made to verify performance and to accumulate data on each part prior to assembly on the stage.

The operation and accuracy of the indication meters on the stage interface set monitor panels or on an appropriate test station shall be verified prior to testing the rate gyro package.

For those cases where the stage is in a horizontal position during assembled stage checkout, the rate gyro package shall be removed and levelled at a location adjacent to the stage prior to testing.

Prior to the final determination of rate gyro assembly location on a stage, the rate gyro tests shall be made at each of the initially specified locations along the stage by moving the rate

gyro assembly to each of these locations. Stage power is required for these tests and shall be furnished via the stage networks. These tests may be partially automated and run from the appropriate test station. A computer program for these tests shall also be provided and verified prior to use in the assembled stage tests of the rate gyros.

2.11.10.3.3 Functional Description

With the stage control system power on and the rate gyros on, signals via an appropriate test station and the stage interface set shall be applied to the test torque coils of each of the rate gyros. These currents shall be monitored at the stage interface set or at an appropriate test station. In addition, the correct functioning of the rate gyros shall be monitored by observing the rate gyro output signal via the stage interface set panel meters or on an oscillograph recorder. These tests shall be applied, in turn, to the pitch, yaw, and roll rate gyros, where applicable.

2.11.10.4 Control Accelerometer Tests

2.11.10.4.1 Test Objectives

The objectives of the assembled stage tests of the control accelerometers are to verify the proper functioning of the pitch and yaw control accelerometers and the associated electrical support equipment.

2.11.10.4.2 Test Requirements

The prerequisites to the assembled stage testing of the control accelerometers shall be as follows:

- a. Assembly on the stage shall be completed.
- b. Checks on component mounting and alignment shall have been made.

- c. Component testing of the control accelerometers shall have been made to verify its performance and to accumulate data on each part prior to assembly on the stage.

For those cases where the stage is in a horizontal position during assembled stage checkout, the pitch and yaw control accelerometers shall be removed and leveled at a location adjacent to the stage prior to testing.

Prior to the final determination of control accelerometer location on a particular stage, the control accelerometer tests shall be made at each of the initially specified locations along the stage by moving the control accelerometer package to each of these locations.

The operation and accuracy of the indication meters on the stage interface set monitor panels or on an appropriate test station shall be verified prior to testing the control accelerometers. Stage power is required for these tests and shall be furnished via the stage networks. These tests may be partially automated and run from the appropriate test station. A computer program for these tests shall be provided and verified prior to use in the assembled stage tests of the rate gyros.

2.11.10.4.3 Functional Description

With the stage control system power on and the control accelerometers on, signals via an appropriate test station and the stage interface set shall be applied to each of the control accelerometers. These input signals shall be monitored at the stage interface set or at an appropriate test station. In addition, the correct functioning of the control accelerometers shall be monitored by observing the control accelerometer output signal level via the stage interface set panel meters or

on an oscillograph recorder. These tests shall be applied in turn to the pitch and yaw control accelerometers.

2.11.10.5 Auxiliary Control System Assemblies

2.11.10.5.1 Test Objectives

The objectives of the auxiliary control system assemblies (i.e., reaction control devices) checkout during assembled stage tests shall be to verify that the initiation, actuation, duration, and decay of the flow through each reaction control device meets the designated performance specifications.

2.11.10.5.2 Test Requirements

Prior to assembled stage testing of the reaction control devices the following prerequisites shall be met:

- a. Assembly shall be complete.
- b. Checks of the mounting and alignment of each reaction control device shall have been made.
- c. Component level tests shall have been made to verify performance and to accumulate data on each of the reaction control devices.

Stage power is required for these tests and is furnished via stage networks. Stage vicinity equipment shall be used to furnish such items as pressurized gas to the reaction control devices during these tests. Each of these tests shall be controlled and monitored via an appropriate test station. These tests shall be performed only on those stages where applicable.

2.11.10.5.3 Functional Description

With the stage control system power on, stimuli are applied to auxiliary control system which pulse the reaction control device on and allow flow through the reaction control jets.

Measurements of the actuation, duration, decay, and deadband characteristics of the device are compared with specified values.

2.11.11 Steering Over-all Test

2.11.11.1 Test Objectives

The objective of the steering over-all test during assembled stage tests is to prove the compatibility of the thrust vector control system with the stage networks.

The objective is to eject the umbilicals and prove the stage can function without the power and control cables connected to the GSE.

2.11.11.2 Test Requirements

- a. Prior completion of the stage networks testing and the engine gimbaling system checkout.
- b. The RF and telemetry systems are not active during this test.
- c. The measuring system is active to the extent of monitoring the hydraulic and gimbaling system.
- d. Apply power to the stage and place the system in a ready to fire status.
- e. Give simulated command to the engine gimbaling system.
- f. Initiate firing command and allow the sequence to proceed normally with liftoff given by ejecting the umbilicals.
- g. Continue the flight sequence until all timing and flight operations have ceased.
- h. Analyze all records taken during the test.

The proper, safe shutdown procedure shall be established so that power may be removed from the stage and ground support equipment in case of serious malfunction.

2.11.11.3 Functional Description

Initially, the stage systems and ground support equipment shall be brought to a state of readiness in order to accept the automatic sequence initiated by the firing command. That is, the networks personnel shall verify that interconnections, power, recorders, and countdown clock are in a state of readiness. The stage personnel shall connect all power supplies, control components, auxiliary hydraulic pumps, cables, and pressure switches. The pneumatic personnel shall verify all pneumatic connections and load the required manifolds.

Power shall be applied, the required substitution and simulation sources shall be turned on, personnel safety devices shall be energized, and certain preparatory control operations shall be performed. All indicators shall be monitored for proper status. Examples of the more important indications that shall be displayed are power monitoring, full dispersion safe, ignition safe, all plugs connected, fuel vents closed, all supports supporting, all manual locks in, DCR signals blocked, stage cutoff safe, safety relays installed, and arming units safe.

Examples of the important steps in the setup of the controls for the stage systems are as follows:

- a. Over-all test switch to plug drop.
- b. Flight and cutoff timers to automatic.
- c. Tail plugs to automatic.
- d. Long and short masts to normal.
- e. Fuel and LOX to simulate.
- f. Engines to thrust correct.
- g. LOX and fuel levels normal.
- h. Pressurize all spheres.
- i. Open LOX and fuel fill and drain and replenish valves.
- j. Release pressure on for umbilicals.
- k. Arm fuel dispersion and safety relays.
- l. Turn on program device.
- m. Open LOX manifold and all prevalues.
- n. Servo valve amplifier on.
- o. Turn on and check command destruct receiver signals.

- p. Test on and off indication for fuel dispersion.
- q. Test power transfer and return.
- r. Arm ignition.

The following types of tests are performed:

- a. Simulated commands are applied to the engine gimbaling system and the engine gimbaling system shall be monitored for proper response.
- b. A firing sequence is performed. The action-initiate-firing command starts an automatic sequence. The actions shall be controlled by the sequence timer and the action status shall be indicated.

Examples of the more important indications are as follows:

- a. Fuel vents close.
- b. Fuel tanks pressurized.
- c. Boat-tail purge normal.
- d. LOX bubbling.
- e. LOX replenish.
- f. Relief and vent valves close.
- g. LOX tanks pressurized.
- h. Gas generator LOX injector and thrust chamber fuel injector purge.
- i. Power transfer.
- j. Long mast disconnected and retracted.
- k. Ignition.
- l. All engines running.
- m. Thrust commit.
- n. Supports retract.
- o. Launch commit.

The simulated liftoff test shall consist of ejecting all umbilicals. Indication of liftoff shall be provided at the electrical test station. Pressurizing valves in the GN₂ lines shall be individually checked for proper operation. Fuel level low shall be simulated. This shall initiate in-board engine cutoff and shall start the program to initiate outboard engine cutoff sequence. In addition, these tests shall include an approved

procedure for emergency cutoff, for removal of power from the stage and ground support equipment, for returning all controls to their pretest condition as well as proper venting procedures to remove pressure from the pneumatic system.

During the above testing operations, all pertinent parameters shall be recorded on the appropriate sequence or event recorder.

2.11.12 RF Compatibility Test

2.11.12.1 Objectives

- a. To determine if any interaction exists between RF systems.
- b. To determine if the RF systems are adversely affected by the operation of other electrical and electronic equipment.
- c. To determine if other electrical and electronic equipment is adversely affected by the operation of the RF systems.

2.11.12.2 Requirements

Prerequisites for this test are:

- a. The completion of the RF and TLM systems checkout.
- b. The frequency allocation analysis.
- c. The acquisition of valid data on the susceptibility threshold of each RF system.

Parameters to be measured are those normally measured to check the operational state of the system; e.g., receiver AGC voltage and various RF measurements in the frequency ranges of interest.

All RF systems including TLM will be active for this test as well as any electrical or electronic subsystem capable of generating a discrete frequency.

The following requirements apply to the Frequency Allocation Analysis Review:

- a. The results of the frequency allocation analysis are carefully reviewed to determine all fundamental, harmonic, subharmonic, beat, etc., radiations possible during normal operation of the vehicle system. In the case of multistage vehicle system, the frequency allocation analysis for each independent stage shall be included in this review.
- b. Particular attention shall be focused on deviation and beat frequency components that might result in an incompatible electromagnetic environment. This review shall include all transmitter frequencies and associated harmonics through the eighth order as well as oscillator frequencies through and inclusive of the third harmonic.
- c. The receiver review shall be considered from the standpoint of major spurious response characteristics, i.e., local oscillator, $2 LO \pm IF$, $3 LO \pm IF$, $LO \pm IF$, $2 (LO \pm IF)/2$, image frequencies, and one or more IF frequencies as applicable. Intermodulation products and multiplier functions shall be determined and analyzed.

The following requirements apply to the Susceptibility Data Review:

- a. The radiated susceptibility data for each subsystem comprising the vehicle system shall be carefully reviewed for the purpose of determining all susceptible frequencies coincident with the fundamental, harmonic, subharmonic, beat, etc., frequencies indicated by the frequency allocation analysis.
- b. The susceptibility levels for each system shall comply with the applicable portions of this specification prior to installation in the vehicle system.

Two separate radiated compatibility tests as specified below shall be performed:

- a. All vehicle subsystems shall be energized one at a time until all subsystems are operating. The response of each subsystem shall be carefully monitored as other

subsystems are energized and during the simultaneous operation of all subsystems. In no case shall there be a change in indication, malfunction, or degradation of performance of any subsystem caused by the energization or operation of another subsystem.

- b. This test shall be performed primarily to determine the radio frequency subsystems operational characteristics in an electromagnetic environment consisting of discrete frequency signals. All subsystems of the vehicle system capable of generating discrete frequency signals shall be energized. All possible coincident frequencies revealed during the frequency allocation analysis and susceptibility data review performed above shall be carefully monitored. If several coincident frequencies are detected, the signal level shall be determined at the subsystem output. The signal shall be in all cases at least six db below the susceptibility threshold of all subsystems that could be affected by this signal.

Care shall be taken to assure that the high electromagnetic environment due to the energization of the vehicle system transmitter does not result in undesired responses in the measuring equipment.

Three separate conducted compatibility tests as specified below shall be performed:

- a. This test shall be conducted to determine the magnitude and time duration of transient conducted interference in the vehicle system. All vehicle subsystems shall be normally operating during this test and the test shall be performed during that portion of vehicle checkout expected to result in the highest levels of transient interference. Vehicle system monitor points shall be chosen on the basis of accessibility, flight criticalness of the subsystem, and the susceptibility levels of the subsystem. The transient interference signals shall be monitored by means of a sensor that is responsive to both

amplitude and time duration. The input impedance of the sensor shall be sufficiently great so as to not cause any detrimental loading effects on the subsystem under test. The output of the sensor shall be capable of transmitting a no-go signal to a recording device when a transient signal exceeding the subsystem amplitude and time duration susceptibility limits are detected. At no time shall transients with sufficient magnitude and/or time duration result in subsystem change in indication, malfunction, or degradation in performance occur within the vehicle system. The magnitude of all transients shall be six db below and the time duration 25 percent less than the susceptibility threshold determined during the susceptibility data review.

- b. This test shall determine the magnitude of continuous wave interference signals in the vehicle system. All vehicle subsystems shall be operating normally during this test, and the test shall be performed during that portion of vehicle checkout expected to result in the highest levels of continuous wave interference signals. The criterion for monitor points and the method of determining the magnitude of the interference signal shall utilize those procedures established for the transient test as a guideline. The test limits shall require that no continuous wave signal result in vehicle change in indication, malfunction, or degradation in performance. The magnitude of all continuous wave interference signals shall be a minimum of six db below the susceptibility threshold determined during the susceptibility data review.
- c. This test shall determine the levels of broadband interference signals in the vehicle system. The test procedure, monitor point, selection criterion, etc., shall be identical to those in the continuous wave compatibility test. The limits shall require only that the magnitude of broadband interference signals does not result in a change in indication, malfunction, or degradation in performance of any subsystem within the vehicle system.

The input impedance of the sensor circuit will vary from component to component but at no time shall this parameter be less than 100 times the normal load impedance of the component being tested. The sensor circuitry shall provide a reference to indicate an excessive interference signal input, shall be physically small in size, and shall provide two insulated input connections, two insulated output connections, and all external power required. It is recommended that the sensors be physically located close to the monitor point to minimize the undesired signal pickup in the interconnecting leads.

2.11.12.3 Functional Description

This test is conducted in three parts. The first part involves a review of the frequency allocation analysis and susceptibility data. The second part is a checkout of radiated compatibility and the third is a checkout of conducted compatibility. The first part is only performed once for each stage and again only when a change in frequency or addition of an RF system is made.

2.11.13 Telemetry Calibration

2.11.13.1 Test Objective

Verify the over-all calibration of the flight instrumentation system, which includes the measuring system and telemetry system, by making a complete end-to-end check of each measurand channel.

2.11.13.2 Test Requirements

Prerequisite for this test is the successful completion of the measuring and telemetry systems checkout. The parameters to be measured and recorded are the outputs of the TLM ground station subcarrier discriminators.

2.11.13.3 Functional Description

All telemetry systems will be active and operating open loop with the ground station. Each channel will be provided with a stimuli which

provides at least a three point check of channel calibration. In n cases this will be the high and low calibration position of the signal conditioner and the run-position which provides the ambient transducer output. The output of the subcarrier discriminators will be compared to the output of the same channel brought over the DDAS. These outputs must compare to within three percent, using the DDAS output as the standard. Those channels which are not returned via the DDAS will have the ground received output compared to the three point calibration curve determined during the measuring systems test. This comparison must be within three percent.

2.11.14 Simulated Flight Test

This test consists of both the Simulated Plug Drop and the Plug Drop test. The Simulated Plug Drop test is run during manufacturing and post-static operations, whereas the Plug Drop is performed only during post-static operations.

2.11.14.1 Simulated Plug Drop (All Systems Test)

a. Objectives

- (1) To verify all of the stage systems can be brought to a state of readiness for firing command.
- (2) To verify that power transfer can be accomplished without any adverse effects on any of the systems.
- (3) To verify that exercising the control system does not adversely effect any of the systems.
- (4) To verify that the stage can be programmed through the firing sequence, simulated liftoff, and all inflight functions operate properly.

b. Requirements

- (1) All of the systems are active, however, there is no need to check the measuring system.
- (2) At liftoff the umbilicals are not ejected. This is necessary to verify that all of the inflight functions, where the response is hardwired to the GSE, occur at the proper time and sequence.
- (3) Perform a power transfer test and gimbal the engines prior to firing command.

- (4) Check the command destruct system prior to firing command.
- (5) Before and after any function, ascertain that the stage responses are proper. Also that they remain proper throughout the test.

c. Functional Description

The Simulated Plug Drop is conducted by setting up a complete vehicle system which includes a stabilized platform, hydraulic actuators, engines, control system, and an analog computer which is used to simulate all of the vehicle flight dynamics. Control system responses are investigated on such problems as bending, stability, actuator-bounce, frequency response, transfer functions, etc. All functions necessary to obtain "launch preparations complete," a firing sequence, and simulated flight are performed. Those functions which cannot be performed for safety reasons, etc., are simulated.

During the Simulated Plug Drop, the stage will be programmed through the same sequence as the steering over-all test with the following exceptions: Retraction of umbilicals will be simulated; inboard cutoff is initiated by simulation of LOX depletion; all stage flight systems are made active. Since the umbilicals are not ejected during this test, the sequence records of networks operation after liftoff are more inclusive than those of other over-all tests. The data from this test will reveal any interaction between subsystems prior to the Plug Drop test. Since all measurements are recorded, the accuracy of transmitted and telemetered information can be verified.

2.11.14.2 Plug Drop

- a. Objectives: The objectives of this test include the ones of the previous test plus the following:
- (1) To verify in detail that the measuring system operates properly and within the proper tolerances.
 - (2) To verify that all of the systems will function properly after the umbilicals are disconnected.

b. Requirements

- (1) Verify prior to firing command that the measuring system is operating within the tolerance.
- (2) Remove all subsystem monitoring equipment that has been used for the lower level testing.
- (3) The countdown should be as close to an actual launch countdown as possible.

c. Functional Description

During the Plug Drop test, the functions performed are identical to those of the Simulated Plug Drop test except that the umbilicals are actually ejected. Inboard cutoff is given by simulating fuel depletion; outboard cutoff by simulating thrust decay of one engine and destruct by command receivers upon termination of the flight sequence. The test results and stimuli are monitored by use of meters, recorders, consoles, etc., at points of interest. Satisfactory completion of this test is evidence that the vehicle is in a flightworthy condition.

APPENDIX A

GLOSSARY OF TERMS

ASSEMBLED STAGE

An assembled stage is defined as a separate stage that has been completely assembled, except for parts that are peculiar to the interfaces with other stages of the launch vehicle and items such as ordnance items which cannot be installed for safety reasons. Ideally, there are no missing parts.

ACCEPTANCE TEST

An acceptance test is defined as any successful test performed on a part of an assembled item, or subassembly as a definite prerequisite to formal transfer of ownership between contractors and/or Government agencies.

CALIBRATED LENGTH

Calibrated length is the length from the center of the actuator at the clevis pin hole on the thrust structure to the center of the actuator clevis pin hole on the thrust chamber which will position the thrust vector to a predetermined angle to the stage centerline.

CAPTIVE TEST FIRING (CTF)

(Also called static test, captive firing, captive test.) Captive test firing is a technique of operating a rocket, missile, or stage on a test stand to determine or check its performance. Normally the engines are operated to full thrust for a predetermined period of time.

CHECKOUT

Checkout is defined as a series of tests for determining whether a device is capable of performing a required operation or function.

CRACKING PRESSURE

Cracking pressure is the pressure at which a pressure operated valve overcomes mechanical forces and begins to move from its normal position.

DIGITAL DATA ACQUISITION SYSTEM (DDAS)

The DDAS is a system which converts analog measurements to digital form and facilitates their transmission to a remote point providing stage data to the ground station in digital format.

FACILITIES

Facilities are defined as those structures other than those defined as GSE which are required to support the test program.

GROUND SUPPORT EQUIPMENT

Ground support equipment (GSE) is defined as any equipment external to a space vehicle and/or stage with the exception of facilities, which is used to fuel, stimulate, activate, test, checkout, launch, monitor, or otherwise control or influence vehicle system performance during prelaunch, launch, or post-launch operations. It includes equipment utilized at assembly plants and other locations, but it does not include the ground electrical test set (GETS) which is used to verify the integrity to the GSE.

INTERSTAGE

Interstage is defined as a structure that joins two stages or a stage and an instrument unit, space capsule, or other payload.

Interstages are used to integrate the stages into a composite space vehicle.

LAUNCH VEHICLE

A launch vehicle is an assembled stage and its interstages; or a system of assembled stages and their interstages which are grouped together for the purpose of propelling a payload along a prescribed flight path.

MALFUNCTION CUTOFF

Malfunction cutoff is that cutoff which is initiated as a result of a fault or certain critical components or the detection of certain conditions which would lead to mission failure.

MANUFACTURING CHECKOUT

Manufacturing checkout is defined as the tests that are successfully performed on an assembled stage to determine that its systems and subsystem are acceptable from an operational standpoint prior to shipping the stage to the static test site.

NETWORK

A network consists of interconnecting wiring and one or more components connected to perform a single, simple function.

STAGE

For purposes of this document a stage is used interchangeably with assembled stage.